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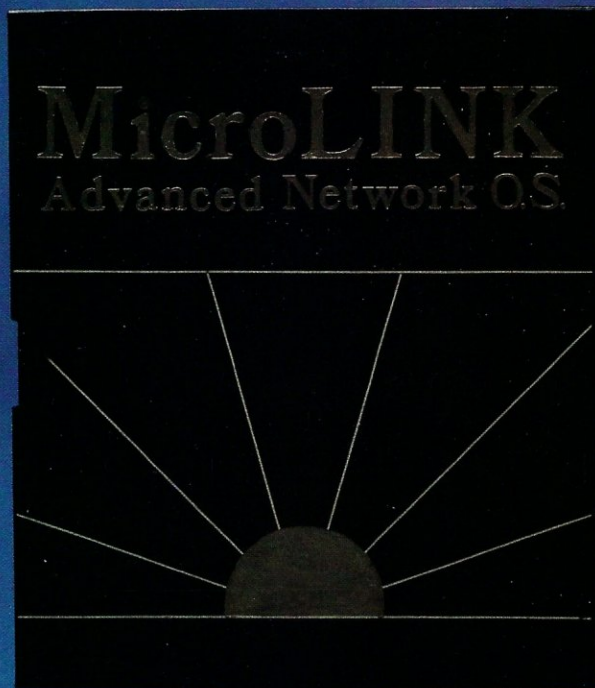
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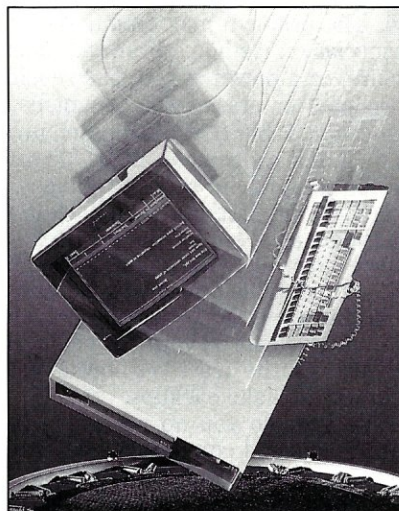
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About the cover: As chief of the corporate data rescue team, you have to be prepared when network disaster strikes. When that alarm rings because a server goes down or a hard disk crashes, you have to be ready to bring the system back on line a.s.a.p. and restore any data that may have been lost. In this issue we hope to help you strengthen your data safety net with tips on how to back up your network data, ways to restore lost or corrupted files, and a look at new data storage techniques and technologies.

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Data Storage: An Ounce of Prevention . . .

Is there a system integrator, or one of his clients, who has not trashed data on a hard disk? I am sure it has happened to all of us at least once. The problem may be due to defective hardware, a bug in the software (especially if it's home brewed), an operator error, a malicious user, a power failure, or a power surge. The result is that invariably one or more files are corrupted or erased and cannot be read by DOS. In severe cases, the File Allocation Table (FAT) is messed up and it may be too time consuming to try to fix it. If it happens on a LAN file server or a multiuser system's disk, a lot of people are going to be very unhappy.

Hence, the first rule is to backup your hard disk and keep the backups as up-to-date as possible. Making backups is an annoying chore. It takes time and effort and is not seen as productive. But when that failure occurs, backups save you considerable time in regenerating lost data.

In this issue, Ed Dowgiallo provides many valuable tips on how to protect the valuable data on your hard disk, and the data on your clients' disks. Among other things, he describes how to make your applications more robust, and the best way to make backups.

But what do you do when you have no backup? There are a number of consultants and companies who specialize in restoring corrupted hard disks and files. You can pull the drive and ship it to them and wait a few weeks while they probe the drive and manipulate the bits. Or you can try to restore the files yourself. To help you do this, Greg Staples, whose business is restoring corrupted disks, lets you in on many of the techniques the pros use.

Of course, there are a number of commercial and public-domain packages designed to help you repair damaged hard-disk files. Steve Leon reviews some of the commercial packages that are available while Bob Blacher reviews the public domain repair options in his column.

Dealing with trashed hard disks is an important concern for system integrators and hence we decided to focus an issue specifically on this topic. It took quite a bit of work to put it together, but we learned a great deal and are confident that you will find this information very useful.

So Long, It's Been Good To Know You

Over the past eight years, I have been the Editor of *Micro/Systems Journal*, and earlier *Microsystems*. In that time, there have been large and rapid changes in the computer industry. Personal computers were introduced into the office and factory and their roles have increased dramatically. PC LAN technology and PC-based multiuser operating systems such as UNIX have matured and taken over tasks that were previously the domain of large mainframes. The systems integrator who installs and maintains these systems has now become a key person in the industry.

Micro/Systems has changed with the industry, and our coverage of areas such as LANs and multiuser systems has increased over the years to support the growing number of our readers who have become systems integrators. Now the magazine is taking a big step to meet our readers' needs. Hence, with the January 1989 issue, the magazine will change its title to *LAN Technology*.

With this change, I will be retiring as Editor. I have been editing the magazine, and its predecessor, for eight years. To be an editor of a computer journal for that length must set some kind of record in this industry. It is time for me to retire. Lennie, Don, and Susan are also stepping down to make room for some fresh blood.

We wish to thank you, our readers, for your support. We also wish to thank our authors for their outstanding articles. Theirs was primarily a labor of love and discovery. We think that we have learned as much from editing *Micro/Systems* as our subscribers did from reading it.

Again, thank you for your support and our best wishes to you for a happy holiday.

Sol Libes

Sol Libes
Editor

LAN and Multiuser PC Integration MicroSystems JOURNAL

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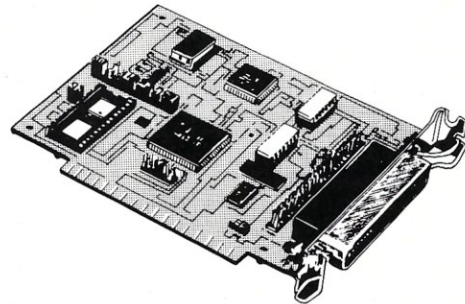
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News & Views

by Sol Libes

Random Rumors & Gossip

Look for **IBM** to introduce a "dramatically enhanced" RT workstation within the next month or two that is capable of 10-mips performance. IBM is a small player in the workstation marketplace and its RT has not done well competing against workstations from **Sun Microsystems**, **Hewlett Packard**, and **Digital Equipment Corporation** (DEC).

In the meantime, **Sun Microsystems** is expected to shortly introduce a new, high-performance, 68030-based workstation that will compete with products from **Next Computer** and **Apple**. The system will add to Sun's existing line up of 80386, 68020, and SPARC-based workstations. The SPARC-based system is reported to be the poorest sales performer in the Sun line.

IBM and **Compaq Computer** are rumored to already have prototype systems based on Intel's new 80486, 32-bit microprocessor up and running in the laboratory. Both companies are in a neck-and-neck race to be the first to release a product. Look for an introduction as early as the late spring 1989, with limited production units becoming available in the fall.

Compaq Computer is also rumored to be planning to introduce a system specifically designed as a turn-key LAN file server packaged with the Novell NetWare LAN operating system.

And, now that **Novell Inc.** is out of the hardware business, look for the company to implement its NetWare LAN operating system in other system environments. The Apple Macintosh is the first NetWare environment rumored to be on the list, with UNIX to follow along with some proprietary systems.

Microsoft is known to be working on a relational database with introduction rumored for mid-1989. This raises questions regarding Microsoft's agreement with Ashton-Tate which designates dBASE IV as a front end to the Microsoft/Sybase database engine, SQL Server. No doubt Ashton-Tate's many delays in releasing dBASE IV have something to do with Micro-

soft's database plans.

And **Microsoft** is rumored working on a multiprocessor version of OS/2 in an attempt to improve the operating system's performance and capabilities. If this is true, this new version of OS/2 would be offered in addition to the 80386 version, which is currently in development and expected out in late 1989.

Extended AT Bus Standard Moves Forward

The rest of the industry has finally come up with a response to IBM's attempt at "big-stick" marketing. The little guys have pretty much agreed to pay IBM a royalty of one percent on past, present, and future PC/XT/AT clone sales. And, the larger companies have negotiated no-fee cross licensing or lesser royalties. However, the companies have balked at IBM's five percent royalty demand on PS/2 compatibles using the MicroChannel Architecture (MCA) and have devised a clever way around it (or maybe a way of pressuring IBM to reduce the royalty). Compaq Computer Corp is leading the move and so far more than 70 companies have joined with it.

The gambit is to create the Extended Industry Standard Architecture (EISA). EISA is an extension to the standard AT bus that the designers claim provides performance and features comparable to IBM's MCA bus as well as compatibility with most AT and XT plug-in cards. EISA will have a 32-bit-wide address and data paths and a high-speed DMA burst-mode data transfer, and it will support multiple CPU boards.

These 70 companies have a much larger share of the PC-compatible market than IBM and hence, when they act in concert, their actions must be taken very seriously. In other words, IBM has a new worry. Based on past experience, IBM will react quickly, most likely with lower pricing and distribution counter tactics that will apply great pressure to the cloners.

Intel and Chips and Technologies are rumored to be already developing interface chip sets for the new EISA bus. Microsoft and Phoenix Technolo-

gies also have agreed to provide software support. Although formal details have yet to appear, many expect the first EISA-based systems to be introduced as early as next summer and shipments to begin late next year. Since there is little current demand for MCA-compatible computers the companies developing EISA appear to have a time window of opportunity.

It will be interesting to see how IBM reacts to this new development. I suspect it will improve the performance of the MCA, negotiate more favorable MCA royalty terms with MCA cloners, and deeply cut prices on competing products. IBM is not about to give up any more market share without an aggressive fight.

EISA is also expected to support the forthcoming 33-MHz 80386 and 80486 chips. However, the EISA bus may run out of steam when the 50-MHz processor chips appear in another 3-4 years.

PC Industry Downturn Predicted for 1989 - 90

Over the last four years, the personal computing industry has become topsy-turvy with cyclical and seasonal ups and downs. This year, 1988, was an up year with an estimated 38 percent rise in sales for the industry after a deep recession in 1985-86. And prognosticators are predicting only a 10 percent growth rate for next year and a downturn for 1990.

The first half of 1988 saw a strong sales upturn, with a softening in the second half of the year. Memory chip shortages and resulting higher prices in the first half evaporated in the second half as supply caught up with demand.

The 80286 market appears to have reached a plateau and is expected to begin decreasing as the 80386 market continues its unexpectedly rapid climb. The 8088 market peaked in 1987, and these systems are now relegated to the very low price-competitive end of the market. The 80286 market now appears to be quickly following in the footsteps of the 8088 market.

IBM has been particularly hurt by the business downturn with dealers reporting huge inventories of PS/2 systems. If IBM decides to cut prices to move this inventory, another price war is expected to develop. This is what happened in the last industry downturn.

Quotations of the Month

"There's nothing the MicroChannel can do that EISA can't do better," Rod Canion, Chief Executive Officer, Compaq Computer. □

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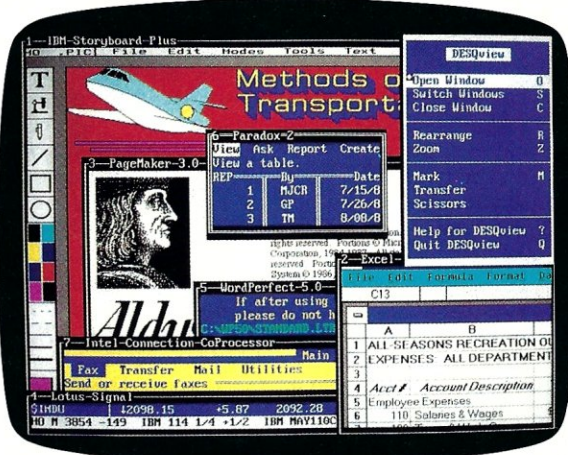
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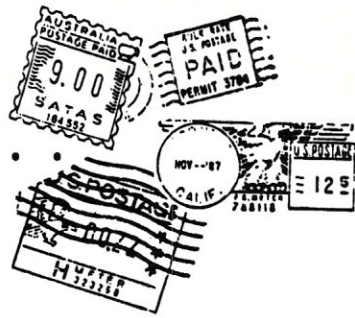
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Requires DESQview or QEMM-386 registration card on file at Quarterdeck or included with upgrade order; upgrades free to owners who show proof of purchase after August 1, 1988. Quarterdeck priority service users: 33% discount from upgrade price plus sales tax and shipping/handling. *Just present proof of purchase of any multitasking operating environment—the cover of your manual will do—and send it to us along with the appropriate payment plus shipping, handling and tax.

CIRCLE 86 ON READER SERVICE CARD

there is mail . . .



Comparing Apples and Oranges on VINES

Dear Editor:

A friend called my attention to William Wong's article comparing Novell NetWare to Banyan VINES ("Novell NetWare and Banyan VINES/286," *Micro/Systems*, July 1988), and while I found Mr. Wong's description of both products to be generally accurate, he seriously understates VINES's performance problems.

I'm a consultant who recently had to come to the aid of a non-profit organization that had fallen six months behind in managing its donor database because one of its Banyan servers was overwhelmed by just six data entry operators. The organization had two Banyan 68000-based floor units running VINES 2.1. Each had 7 MB of memory, 370 MB of disk space, and Ethernet cabling. The six data entry people were running a heavily customized copy of Network Paradox2 on 10-MHz Wyse 286 workstations, and they essentially had one of the Banyan servers all to themselves. (The second served primarily as a very expensive print server for the other 20 workstations.)

From the LAN comparisons I had already read in *PC Magazine* (January 27 and April 28, 1987), I had a pretty good idea what the problem was: VINES's steep degradation curve under increasing disk-intensive loading. With Paradox2 and only six concurrent users, the response time was abysmal. The solution was straightforward. I got a copy of Novell's SFT NetWare 2.1, loaded it onto a Wyse 386 computer with just 2 MB of memory and a single CDC 300-MB Wren IV drive, connected the six workstations via ARCNET, copied all the software over, and got roughly a tenfold increase in performance under heavy loading. (I kept the Ethernet in place so that the Banyan became a backup server and to permit data transfers between the two networks.)

VINES is a fine, sophisticated package with many strong points, and I can see that it would be more appropriate than NetWare for certain applications. But in this case, it was simply a very poor choice, as it would be for anyone needing heavy-duty, multiuser database crunching. Going to a bigger Banyan server to solve serious performance problems, as Mr. Wong suggested, is unlikely to do much more than generate a big bill and bigger headaches.

Bernie Conneely
Owner, TOBERCON
Charlestown, Mass.

From the Author: Unfortunately, Mr. Conneely is making a classic apples-and-oranges comparison between the 386 server running Novell SFT NetWare 2.1 and the Banyan BNS server running VINES 2.10. Three things changed: the server, the network operating system, and the storage capacity. The latter will make a difference if the CDC Wren's speed is significantly different or the memory used on the 80386 system is 32-bit memory versus the 16-bit memory found in the BNS. Capacity makes little difference given the sizes discussed.

The review addressed Novell's NetWare 2.0 and VINES 2.10, the products available at the time the comparison was made. Novell's SFT NetWare 2.1 is a newer version of the network software with better performance. It is comparable to VINES 3.0, which evidently was not considered. Performance with small record sizes under VINES 2.10 is poorer than NetWare as mentioned in the article. However, VINES 3.0 performs significantly better than VINES 2.10, especially in the area of small record sizes utilized in database applications such as the one mentioned. The performance increase using the new server configuration may have been achievable by simply upgrading to VINES 3.0.

Changing servers also accounts for

a major difference in performance. The 68000-based BNS is comparable to an 80286 PC. Likewise, most 80386 systems run at 16, 20, or 25 MHz, which is higher than the BNS. There is also the issue of 16- versus 32-bit memory. The 80386 server compares with the newer Banyan CNS, which is also based on an 80386. VINES/386 will also run on the 80386 server installed by Mr. Conneely.

The switch from Ethernet to ARCNET sounds a bit odd since Ethernet provides better throughput than ARCNET. ARCNET tends to be cheaper overall, but having two installed wiring systems is both confusing and more expensive to maintain. Having two network operating systems only makes things worse.

Switching network software in mid-stream can be costly in both time and effort. It is best to check out all the alternatives before making such a decision, and, as in medicine, it pays to get a second opinion. In any case, VINES 3.0 and SFT NetWare 2.1 are both excellent choices to put on your network server, and they are the proper products to compare on the same platform.

Bill Wong

Data Integrity: A Hardware/Software Balancing Act

Dear Editor:

In the September issue of *Micro/Systems* appears an article by Tom Hoops and Ed Rought extolling the virtues of Btrieve ("Using Btrieve with Turbo C and Turbo Pascal"). I don't mean to pick on the authors or detract from their excellent article. Indeed, their observations help point out some elements of a generic problem in our industry. At the top of page 55, second column, a real and threatening problem is revealed by the statement, "If the file server of a Novell network goes down, the file integrity information in the RAM cache disappears, never to be seen again."

To me, this seems like a very curious thing to read after having read earlier in the article, "The companies that own networks expect error-free software, and so do their attorneys." It seems to me that a double standard is being applied here. The message seems to be that software must meet a higher standard of data integrity than the hardware on which it runs.

Another message that comes across loud and clear is that it's okay to trade off integrity for performance; "... the enormous performance benefits gained by NetWare through its disk caching scheme outweigh the data integrity problem..." This does not make a whole lot of sense. The double standard has already established

(continued on page 69)

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<i>Computer Language</i>	February 1986, '87	
<i>Dr. Dobb's Journal</i>	August 1986	
<i>PC Magazine</i>	Jan. 27, 1987	(80386 version)
<i>Dr. Dobb's Journal</i>	July 1987	(80386 version)
<i>BYTE Magazine</i>	November 1987	(80386 version)

• Professional Pascal™:

<i>PC Magazine</i>	Dec. 29, 1985
<i>Computer Language</i>	May 1986
<i>PC Tech Journal</i>	July 1986
<i>Journal of Pascal, Ada, & Modula-2</i>	Nov.-Dec. 1986
<i>BYTE Magazine</i>	Dec. '86, June '87 (80386 version)

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CIRCLE 94 ON READER SERVICE CARD

by Don Libes

C and Me

This column is a summary of the state of C. I think it is also appropriate to talk a bit about myself since this is my last column for *Micro/Systems Journal*. The magazine has been focusing more closely on network technology to meet the evolving needs of its readers, and a column devoted exclusively to C programming does not fit in with that new direction. Next month, a new programming column will make its debut, providing information and tips about programming in C and other languages for a LAN environment.

It has been very enjoyable doing this column, especially receiving letters that readers have sent to me in response to what I have written. For those of you who have a deeper interest in C programming there are now two magazines that specialize in the C language:

The C Users Journal
2120 W. 25th Street, Suite B
Lawrence, KS 66046-9972

The C Gazette
1341 Ocean Avenue #257
Santa Monica, CA 90401

There are also many magazines that carry C columns among their other wares, such as *UNIX Review*, *Computer Language*, and *Dr. Dobbs Journal of Software Tools*.

While I have not yet made a decision on where, I will certainly continue to write, whether it be in another magazine or as a book. I recently completed a book called *Life With UNIX*, published by Prentice Hall.

Don Libes is a computer scientist in the Washington, D.C., area specializing in artificial intelligence. He is also the author of Life With UNIX, published by Prentice-Hall.

It covers UNIX in much the same style that I have covered C in these columns. I include a lot of humor, anecdotes, and history, while giving you a "between the lines" explanation of what UNIX is.

Now I'm going to take a much deserved rest to think about my next project. M&T, the organization that publishes *Micro/Systems Journal*, has expressed interest in collecting all the columns I have written during the past five years and publishing them in book form. In the meantime, if you wish to contact me, you may do so either through my network address, libes@cme.nbs.gov (or uunet!cme-durer!libes), or by mail at Box 1192, Mountainside, NJ 07092.

You may be amused to learn that I actually started writing the C Forum as a "favor" to my dad. In fact, he didn't even pay me at first. (Can you believe it? Of course, he never paid me to mow the lawn either.) He knew I was semi-literate (especially when it came to asking for the keys to the car), and C seemed like a language that might be mildly interesting to a small handful of readers.

Since that time, interest in C has mushroomed beyond my expectations. I had no idea that there would be dozens of companies selling C compilers, interpreters, and debuggers, or that hundreds of software houses would use C as their primary system programming language.

C is truly a *lingua franca* of system programming, having surpassed long time favorites such as BASIC, Pascal, FORTRAN, Cobol (thank God), and Assembler. As a direct competitor, only Ada stands a chance of reaching comparable popularity. As yet, however, Ada has not reached the critical mass required for mass acceptance.

An important event in C's lifetime is the establishment of a standard

that rigorously defines the language, libraries, and host environment. The ANSI X3J11 committee has been working on a C standard for several years. As is typical of standards, final resolution of the standard has dragged on much longer than planned. It appears that the standard will not be ratified before the second half of 1989. However, the draft is 99 percent complete and many people are already advertising products as "ANSI C." The standard is also referred to as "XJ311," or simply "Standard C."

Many vendors already support the primary bulk of new additions to the C language offered by Standard C, such as function prototypes. The draft standard has made only a few additions to the language. The primary work was integrating different working practices from existing C compilers.

There are still obvious gaps in the specifications, but they have been substantively clarified and noted, so that portable coding practices are much easier to implement than they were without the guarantees made by the standard. Therefore, while it is easy to gripe about what the X3J11 committee did or did not do, I think it is time to rally behind this standard. It is a good thing.

The current draft may be ordered from:

Global Engineering Documents
2805 McGaw
Irvine, CA 92714
(714) 261-1455
(800) 854-7179

Ask for the X3.159 draft standard. The price is \$65.

The current X3J11 meeting schedule is:

December 12 - 16, 1988
Seattle, Wash.

April 10 - 11, 1989 Phoenix, Ariz.

For more information on the Standard C, contact:

Thomas Plum
Vice Chair, X3J11 Committee
Plum Hall Inc.
1 Spruce Avenue
Cardiff, NJ 08232

C++ Gaining Ground

Another very important development you should be aware of is C++. C++ is one of many attempts to add modern ideas to the C programming language. C++ is particularly popular since it is upward-compatible with C, mean-

ing that C programs can be compiled with no (well, ... few) changes by C++ compilers. Thus, you can use a C++ compiler with no investment in retraining, only using or experimenting with a new feature when you decide to. C++ also retains the efficiency inherent in C and is link-compatible with C.

The more important features of C++ include:

- Data abstraction, including data hiding, operator overloading, guaranteed initialization, and cleanup;
- Object-oriented programming, including derived classes (single inheritance) and virtual functions;

- Other enhancements, including scoped and type constants, inline functions, overload function names, and free store operators (*new* and *delete*).

You can read more about the language in *The C++ Programming Language* by Bjarne Stroustrup, (Addison Wesley, 1986).

C++ has actually been in use for more than five years now, and parts of the Standard C were heavily influenced by C++ (e.g., function prototypes).

Several major vendors, including AT&T, Microsoft, and Sun, have already begun using C++ as their pri-

mary system programming language, which should impress upon you that the substantial worth of C++ is already being appreciated. A few of the companies selling C++ compilers are AT&T, Apollo, Guidelines Software, Oasys, Oregon Software, and Zortech.

C Interpreters

Another important development in the world of C is that of C interpreters. I devoted an entire column to that topic in the January/February 1986 issue of *Micro/Systems Journal* and reviewed three interpreters in the following issue. While the implementations have improved and the number of interpreters has grown, the concept remains the same. Interpreters allow you to make a small code change and

*... the
environment
these interpreters
provide allows
immediate
execution of C
statements.*

run the program without recompiling.

In addition, the environment these interpreters provide allows immediate execution of C statements. So you can type in C statements and, when you press Return, they are executed. For example, I typed in the following while using Instant-C from Rational Systems. It prompts with a #:

```
# int i;
# for (i=0;i<10;i++) printf(
                                "%d", i);
1 2 3 4 5 6 7 8 9 10
```

Impressive, isn't it? The idea really works in practice, too. And if you make a mistake, the interpreter puts you in the editor with the cursor positioned where the error was detected. In my earlier review of C interpreters, I pointed out that all of the interpreters had some limitations, and that they were primarily good only for learning C or fooling around with small programs. Since then, however, the interpreters have improved dramatically. In addition, most machines have much more memory than they did two years ago. If you want the benefits of interpreters, you must realize that your computer must not only hold the machine instructions for your program in memory, but the

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CIRCLE 51 ON READER SERVICE CARD.

source, an intermediate form used by the interpreter, the symbol table, and the interpreter, too!

Some companies selling C interpreters are Borland, Catalytix, Gimpel, IMPACC, MicroPro, Microsoft, Rational Systems, Sabre, and Stepstone.

Compiling with GNU CC

The Free Software Foundation (FSF) has made available a free C compiler called *gcc*. As with all the products of the FSF, *gcc* is:

- **Very high quality.** For example, optimization includes: invariant code motion out of loops; common subexpression elimination; automatic register packing; constant propagation and elimination of consequent dead code; copy propagation; elimination of dead stores; jump optimization including cross-jumping; delaying of stack adjustments after function calls; arithmetic performed in sub-word types when appropriate, etc.
- **Unsupported.** Strictly speaking, FSF offers no support. However, *gcc* is widely used and there are many unofficial maintainers, as well as a dedicated electronic mailing list and the Usenet newsgroup. FSF records known bugs and fixes.
- **Source form.** It is distributed in source form so that you change it as you desire. (Also, so you can fix bugs!)
- **Free, but not public-domain.** FSF retains copyright over the software. However, you can use, change, make copies, and distribute as you desire, as long as you do not charge for it, or remove the FSF copyright statements.

As I mentioned, *gcc* is of very high quality. Indeed, many programmers have discarded the compiler supplied by their manufacturer and turned to *gcc* instead. Sometimes, this is because *gcc* is a better compiler. Another reason is that *gcc* is portable between a large number of machines. If you support software that is portable, it is much easier to keep it running on one compiler rather than 10.

Furthermore, *gcc* is tracking the ANSI C standard quite closely, and it is likely to incorporate features from the standard more quickly than any vendor.

gcc also comes with some auxiliary software, such as *gdb*, the GNU debugger. The same comments as above hold.

The GNU C compiler can be *ftp'd* from *prep.ai.mit.edu*. The file is called */u2/emacs/gcc.tar*. This includes machine descriptions on existing ma-

chines supported by *gcc*, and extensive documentation on porting *gcc* to a new machine.

If you want more information about GNU, send electronic mail to:

```
gnu@prep.ai.mit.edu
..!mit-eddie!mit-prep!gnu
..!ucbvax!prep.ai.mit.edu!gnu
```

or regular mail to:

Free Software Foundation
1000 Massachusetts Avenue
Cambridge, MA 02138
(617) 876-3296

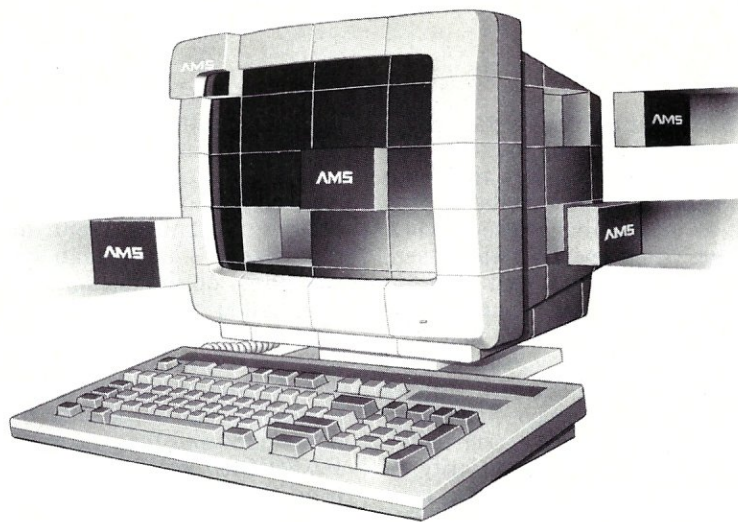
Summary

C and its variants, such as C++, will

remain the workhorses for systems programming during the next decade. Interest and use of C continues to grow at an incredible rate.

Nonetheless, the C language is not for everyone as I have said many times in past columns. C is not applications-oriented; CASE and 4GLs are often more suitable and may be the languages of the future for many high-level tasks. Other tasks, such as small ones or real-time programming, are often more easily done in other languages. Make sure you use C when appropriate and you will reap the benefits of the maturity of the language. □

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CIRCLE 78 ON READER SERVICE CARD

by Stephen Randy Davis

Multitasking Windows, Part II

In the last column I examined a simple windowing package. The set of functions described the way to open a window on the display, write to it, and then close it when finished. When a window was closed, all trace of it was removed from the display. That is to say, it was a pretty standard set of windowing functions (except for the extra features that were left out in the interest of keeping the listing as short as possible).

This set of functions shared a serious problem with the majority of commercial windowing libraries available for the PC (and the Quick Draw windowing functions for the Macintosh as well). That is, only the top-most window may be accessed. Writing to or scrolling any window other than the one on top results in changes in windows other than the one being accessed. This causes general corruption of the display.

The set of windowing functions presented in Listing 1 does not suffer from this limitation. Any one of up to 16 windows are allowed on the display at one time and may be accessed in any order, even if they are eclipsed by other windows. As the background window scrolls text moves up under an overlying window and disappears, only to reappear above the superior window.

Keeping Track of Multitasking Windows

The fundamental problem with scroll-

Stephen Randy Davis is a technical editor for Micro/Systems Journal and a programmer for a defense contractor in Greenville, Texas.

ing background windows lies in the way screen information is normally stored. In our earlier windowing package (see "Turbo Pascal Corner," *Micro/Systems*, November 1988), the current window's information was actually stored on the display itself. The information stored in the window's structure were the characters that were overwritten by the current window. In such a scheme, the area for a window was saved into the window's node and then cleared during *WindowOpen*. *WindowWriteLn* manipulated the window's data on the display. *WindowClose* restored the display by writing the data from the window's node back to the screen, overwriting the now closed window.

The problem with this approach in a multiwindowed environment is that it is very difficult to know where each window is stored, except for the last one. This makes it virtually impossible to access the data in any of these background windows. The only solution, then, is to turn the situation completely around. Instead of keeping the window's information saved in display memory, the data must be retained in the window node. Writing is to the window node. The scrolling operation is carried out on the data in the window node. No matter how many windows might be overlying the current window, its data is saved in one contiguous block in the window node. (Interestingly, since each window's data is saved in its node structure, it is no longer necessary, or even possible, to save the screen data when opening the window.)

Of course, writing and scrolling a block of memory in a window node does not cause it to be displayed.

After every window operation, the data in the window node must be copied out to display memory to make it visible. In Listing 1 this is handled by the function *WindowPaint*. If we assumed that we could only access the topmost window, then *WindowPaint*'s job would be merely a matter of copying the data to the proper place in screen memory. As it is, however, *WindowPaint* must check before each transfer to ascertain that the character being written out is not overlaid by some other window. If this is the case, then *WindowPaint* cannot write the character because doing so would overwrite the superior window.

It turns out that deciding which characters should and should not be written is a rather tricky business. Since the *WindowPaint* operation is carried out so often and is so time intensive this check must be very efficient, ideally taking no more than one *IF* statement.

This package assigns a single bit position in a 16-bit word to each window, hence not more than 16 windows may be open at one time. This bit is saved in the field called *Priority* in the window node. Parallel with the actual display, it creates a matrix called *AccessRights*. Each location in *AccessRights* contains the ORing of the windows that occupies the corresponding position on the screen. For example, assume that Window 1 was assigned \$0001, Window 2 \$0002, and Window 3 \$0004. If *AccessRights* [5][10] contains the value \$0005, I know immediately that Window 1 and Window 3 both occupy row 5, column 10 on the screen and that Window 2 does not.

Of course, I still do not know which window is on top and which is below. This is the function of the field *Mask* in the window node. For each window, this variable contains the ORing of all the windows that appear above it on the display. Assuming in our example that Window 3 is on top, its mask would be 0 (the top window's mask is always 0). Window 2, being immediately below 3, would have a mask of \$0004, the priority of Window 3. Window 1, lying below both Windows 2 and 3, would have a mask of \$0006. This reduces the problem of deciding whether a section of a window is visible or not to a single test; a window position is visible on the display if and only if the ANDing of the *Mask* field of a window node and the corresponding *AccessRights* position is 0. Thus, in our example since *AccessRights* [5][10] is \$0005, we know that Window 3 is visible (\$0005 AND \$0000 is 0) and Window



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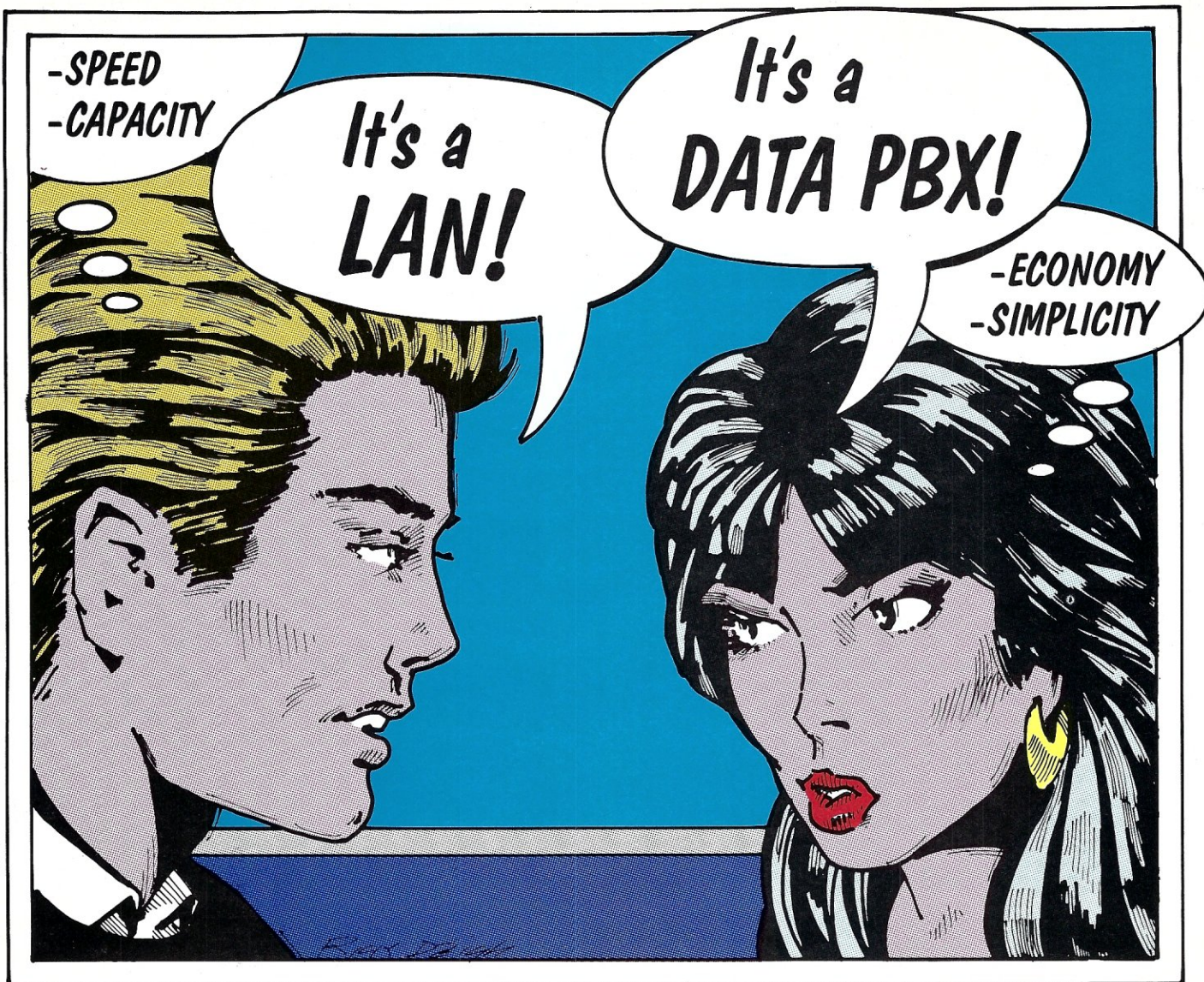
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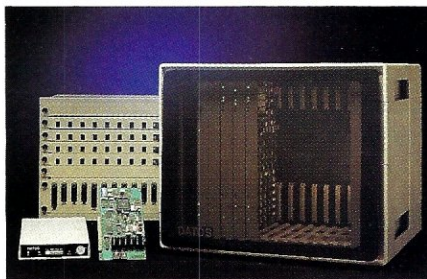


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Listing 1. Advanced Windowing Package

(Advanced Windowing Package -
by Stephen Randy Davis, 1988
This windowing package does not suffer from the single-tasking
limitations of many windowing packages. Specifically, these
windows may be scrolled independently, even windows that are
not currently on top.

```

type
  DataBlock = array [0..1] of integer;
  Strng = string [80];
  WindowNodePtr = ^WindowNode;
  MaskType = Word;
  WindowNode = record
    Signature      : integer;
    DeltaX, DeltaY : integer;
    WinX, WinY     : integer;
    Color          : integer;
    CurrentX, CurrentY : integer;
    Priority, Mask  : MaskType;
    Next           : WindowNodePtr;
    DSize          : integer;
    Data           : ^DataBlock
  end;

const
  cga = $b800;           {offset of CGA/EGA}
  mono = $b000;          {      monochrome screen}
  WinSig = $1234;

var
  Head      : WindowNodePtr; {pointer to the Window List}
  Screen    : array [0..24] of array [0..79] of Word;
              absolute cga:0; {set for cga/ega}
  AccessRights : array [0..24] of array [0..79] of MaskType;

{these procedures are required internally}
{SigCheck - check the node signature to make sure its valid}
Procedure SigCheck (W : WindowNodePtr; Msg : Strng);
begin
  if (W^.Signature <> WinSig) then
  begin
    WriteLn ('Signature Error:', Msg);
    Halt
  end
end;

{WindowAdd - add a window to the window list}
Procedure WindowAdd (Before, W : WindowNodePtr);
begin
  SigCheck (W, 'Window Add W argument');
  SigCheck (Before, 'Window Add Before argument');

  W^.next := before^.next;
  before^.next := W
end;

{WindowRemove - remove a window from the window list}
Procedure WindowRemove (W : WindowNodePtr);
var
  ptr : WindowNodePtr;
begin
  SigCheck (W, 'WindowRemove W argument');
  ptr := Head;
  while ptr <> nil do
  begin
    if ptr^.next = W then
      ptr^.next := W^.next;
      ptr := ptr^.next
    end
  end
end;

{Precedence - calculate the precedence of a window in the list}
Function Precedence (W : WindowNodePtr) : MaskType;
var
  ptr : WindowNodePtr;
  p : MaskType;
begin
  if W <> nil then
    SigCheck (W, 'Precedence W argument');
    p := 0;
    ptr := Head^.next;
    while ptr <> W do
    begin
      SigCheck (Ptr, 'Precedence chain traversal');
      p := p or ptr^.priority;
      ptr := ptr^.next
    end;
    Precedence := p
  end;
end;

```

```

(NewMask - calculate a mask for the current window node)
Procedure NewMask (W : WindowNodePtr);
var
  mask, bit : MaskType;
  ptr       : WindowNodePtr;
begin
  mask := Precedence (nil);
  bit := 1;
  while (bit and mask) <> 0 do
    bit := bit + bit;
    if bit <> 0 then
    begin
      W^.priority := bit;
      W^.mask := not (mask or bit)
    end
  end;
end;

{SetAccess - add the current window to the access list}
Procedure SetAccess (W : WindowNodePtr);
var
  x, y : word;
begin
  SigCheck (W, 'SetAccess window argument');
  with W^ do
    for y := DeltaY to DeltaY+(WinY - 1) do
      for x := DeltaX to DeltaX+(WinX - 1) do
        AccessRights [y][x] := AccessRights
          [y][x] xor Priority
      end;
    end
end;

{WindowPaint - paint the current window to the screen}
Procedure WindowPaint (W : WindowNodePtr);
var
  y, x, offset : word;
  wd, ht       : word;
begin
  SigCheck (W, 'WindowPaint window argument');
  with W^ do
    for ht := 0 to (WinY - 1) do
    begin
      y := DeltaY + ht;
      offset := ht * WinX;
      for wd := 0 to (WinX - 1) do
      begin
        x := DeltaX + wd;
        if (AccessRights [y][x] and Mask) = 0 then
          Screen [y][x] := W^.Data^[offset + wd]
        end
      end
    end
  end;

{Restack - restack the precedence of the windows in the list}
Procedure Restack;
var
  ptr : WindowNodePtr;
begin
  ptr := head^.next;
  while ptr <> nil do
  begin
    ptr^.mask := Precedence (ptr);
    WindowPaint (ptr);
    ptr := ptr^.next
  end
end;

{WindowScroll - scroll the current window by 'count' lines}
Procedure WindowScroll (W : WindowNodePtr; Count : integer);
var
  index, offset, total : word;
begin
  With W^ do
    if count > 0 then
    begin
      CurrentX := 0;
      CurrentY := CurrentY + Count; {carriage return}
      if CurrentY >= WinY then {line feed(s)}
      begin
        Count := CurrentY - WinY + 1;
        CurrentY := WinY - 1;
        Offset := WinX * Count;
        Total := WinX * (WinY-Count);
        for index := 0 to total do
          Data^[index] := Data^[index + offset];
        for index := total to total+offset-1 do
          Data^[index] := Color + Word(' ')
        end
      end;
      WindowPaint (W)
    end;
  end;

{User accessible functions are WindowOpen, WindowClose, WindowWrite
and WindowPop}

```

... continued on next page

Listing 1. (continued)

```
{WindowOpen - open a window of the given size and color}
Function WindowOpen (X, Y, Width, Height, Attr : integer) :
    WindowNodePtr;
var
    W : WindowNodePtr;
    i, j : word;
begin
    New (W);
    with W^ do
    begin
        {Save the data into the window}
        Signature := WinSig; {store signature field in first thing}
        DeltaX := X;
        DeltaY := Y;
        WinX := Width;
        WinY := Height;
        Color := Attr;
        CurrentX := 0; {set cursor to beginning of window}
        CurrentY := 0;

        {Store off the section of screen into the windownode}
        DSize := WinY * WinX * 2;
        GetMem (Data, DSize);

        {Calculate priority of current window}
        NewMask (W);

        {Set the access list for this window}
        SetAccess (W);

        {Now add window to the linked list}
        WindowAdd (Head, W);

        {Finally, clear window and write it to screen}
        for i := 0 to WinY do
            for j := 0 to WinX do
                Data^ [i * WinX + j] := Color;
            WindowPaint (W)
        end;
    end;
    WindowOpen := W
end;

{WindowClose - close and remove the window from the window list}
Procedure WindowClose (Var W : WindowNodePtr);

begin
    WindowRemove (W); {remove window from list}
    SetAccess (W); {now remove its mask}
    FreeMem (W^.Data, W^.DSize); {free up its data memory}
    Dispose (W); {and its node}
    ReStack; {repaint windows left}
    W := nil; {and return a NULL}
end;

{WindowPop - move the window 'W' after the window 'Before' in the
window list}
Procedure WindowPop (Before, W : WindowNodePtr);
begin
    WindowRemove (W); {remove the window}
    WindowAdd (Before, W); {now reposition it}
    ReStack; {and redraw all windows}
end;

{WindowWriteLn - write an ASCII string to the specified window}
Procedure WindowWriteLn (W : WindowNodePtr; OutString : string;
    nlines : word);
var
    i : word;
    Count : byte absolute OutString;
    VertOffset : word;
begin
    with W^ do
    begin
        VertOffset := CurrentY * WinX;
        for i := 1 to count do
            if CurrentX < WinX then
            begin
                Data^ [VertOffset + CurrentX] :=
                    Color + Integer (outstring [i]);
                CurrentX := CurrentX + 1
            end
        end;
        WindowScroll (W, nlines)
    end;
end;

{ExerciseW - test code to write to and scroll the specified window}
Procedure ExerciseW (W : WindowNodePtr);
var
    i : integer;
begin
```

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1 is not (\$0006AND \$0005 is not 0).

Examine Listing 1 closely with this explanation in mind. The function *ExerciseW* called from within the main program is provided merely to exercise the windowing routines. Windows are written and scrolled completely

without regard to their order. In addition, the function *WindowPop* can change the order of the windows on the display by reordering the window nodes, recalculating the *Mask* for each, and then *WindowPainting* the windows back to the display.

```

for i := 1 to 100 do
    WindowWriteLn (W, 'this is just a string', (i mod 3) + 1);
end;

var
    background, W1, W2, W3 : WindowNodePtr;
    x, y : word;
begin
    {initialization section}
    New (Head);                {define a head structure}
    Head^.signature := WinSig; {to point to the window list}
    Head^.next := nil;
    for y := 0 to 24 do        {clear the accessrights}
        for x := 0 to 79 do
            AccessRights [y][x] := 0;
        background := WindowOpen (0, 0, 80, 25, $0700);

    {open a few overlapping windows and exercise them -
     remove this to make this into an Advanced Window Unit}
    W1 := WindowOpen (10, 10, 50, 10, $1300);
    ExerciseW (W1);
    W2 := WindowOpen (20, 5, 30, 17, $4200);
    ExerciseW (W2);
    W3 := WindowOpen (30, 7, 20, 8, $2500);
    ExerciseW (W3);
    ExerciseW (W1);            {scroll background window}

    {change the order of the windows}
    WindowPop (W1, W2);        {pop window1 above window2}
    ExerciseW (W1);            {and scroll it again}

    {remember to close the windows to remove this from the display}
    WindowClose (W2);
    WindowClose (W3);
    WindowClose (W1);
end.

```

Conclusion

I enjoy the windowing provided by the QuickDraw ROMs of the Macintosh and numerous commercial packages on the PC, but I have always been irritated by the inability of these interfaces to handle scrolling of background windows. The first time I saw DESQview with its multiple scrolling windows lying on top of each other, I knew that this problem had a solution. The windowing package presented here can be adapted by any reader to add the ability to access windows in any order, irrespective of how many other windows might be covering it. □

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RESTORING

Network Data Files

by Ed Dowgiallo

Understanding why data disappears from your LAN will make it that much easier to get it back and may help prevent future losses.

On every computer system, sooner or later you will have to repair a damaged file. Such lightning bolts always seem to strike on the evening of the day you had to leave early and didn't bother to run the backup software. If one of your accounting system's files or another file that is equally critical takes the hit, you have little choice but to attempt to repair it as quickly as possible. This problem is magnified when the file resides on a LAN because now an entire department's productivity may be impaired.

Ed Dowgiallo is an independent computer consultant based in Delran, New Jersey. In addition to writing for computer magazines, he does custom design and programming in the area of databases, data communications, and operating system extensions.

How Are Files Damaged?

The first step in knowing what to do about a file that has been corrupted is to understand the basic reasons that file corruption occurs. Recovering files is usually a process of treating the symptoms of a deeper problem. Understanding the relationship of the symptoms to the underlying problems will not only help recover lost data but will aid in the more important task of treating those real problems. If you can diagnose and treat the real problem, you will find yourself involved in less recovery activity. The manifestations of these root problems typically fall under the umbrella of two broad event categories: power interruptions and media failures.

Power Interruptions

Power interruptions can come from a wide variety of sources. The power company is the first that comes to mind. It's usually easy to tell when the power company has "done it to you" since the lights will also go out to draw your attention to the event. Sometimes the problem is more subtle than that, taking the form of a brownout where the power level drops during peak usage times in order to democratically provide equally reduced service to all customers. This type of problem is geographic in nature (after all, the guy next store has the same power company) and is generally best corrected by adding a UPS (uninterruptable power supply) system. A UPS system is usually a big ticket item, but if your application is sufficiently critical or the power company is sufficiently unreliable the expense may very well be worthwhile.

Coworkers are often a source of power interruptions. I've seen situations in which a PC is placed in a "temporary" location where the power cord is run across a high traffic area. Aside from the fact that the practice of running power cords across walkways is an unjustifiable safety violation, the person who trips over the power cord and thus cuts your power could get hurt. In the case where a laptop is attached to the power cord, the computer could be yanked off the table, in which case it, too, will get hurt.



Whenever you string a cable like that on a temporary basis, keep in mind that someone will inevitably trip over that cord.

An often overlooked source of power interruptions is the computer user himself. When you bring in that new hire, a novice from the secretarial pool, a temporary data entry person, or just assign a new duty to someone established in the office, that new person may be unfamiliar with computers or narrowly trained. They may not realize that you can't turn the machine off while the update screen is displayed! This also is a situation that I've seen happen any number of times. Programmers and computer-literate users become so conditioned to properly exit an application that they don't realize that you have to take the time to explain it when training someone. Sure, it's a minor embarrassment when the trainee looks at you like they're being patronized and informs you they already knew that; however, the old saying "Better silly than sorry" fully applies.

When a power interruption occurs, the contents of memory are lost before the application can run the file-close routines to copy the information back to the disk.

Regardless of the particular method of perpetration, a power interruption will usually damage any files that are both open and modified at the time the interruption occurs. This damage usually occurs due to buffer loss, but, in rarer instances, it can also be the result of write interruptions.

Buffer Loss

Buffer loss is the most common mechanism that damages files. When a file is opened, a variety of control information is copied into memory and kept there until the file is closed. This in itself is harmless, however, if that control information is modified, it is only modified in memory until the file is closed. The control information includes the overall length of the file, the memory locations of buffers containing data from the file, and the physical disk locations to which these buffers correspond. The reason for keeping this control information in memory is quite simply to improve performance. Similarly, the memory buffers are also kept for better performance. When doing sequential record reads through the file, buffering can dramatically improve the speed of the application. Even in random-access situations, buffering will reduce the number of physical disk reads and writes that occur.

When a power interruption occurs, the contents of memory are lost before the application has the opportunity to run the file-close routines to copy this information back to the disk. For instance, if you run an application

that creates a file, then turn the machine off before the application closes the file, typically, when you turn the machine back on, you will find a file with the correct name in the directory, but it will have zero length. The file length and other control information were lost when the application did not close the file.

Write Interruption

Write interruption takes place when the software is interrupted in the process of writing buffers out to the disk. You know when your disk is reading or writing buffers to the disk because the disk drive's indicator light flashes when these operations are being performed. Originally, these lights were provided on floppy disk units so that users would not attempt to remove a disk while a disk operation was in progress.

A write interruption is a more serious situation because things may be left in a partially updated state. The computer's operating system maintains its own control information on disk. Whenever you run the DOS DIR command, you are looking at a display of some of this control information. All the information in a disk directory is contained on the disk as data. Normally, applications only manipulate this data through a file system subroutine provided by the operating system.

When a write interruption occurs, it may occur at a point where the operating system has copied some but not all of its control information back to the disk. This will not always happen; you may get lucky and the write interruption will occur between two disk updates. In this case, the result will be the same as in a buffer loss.

Related Interruptions

Related to power interruptions are the interruptions that take place when a machine is rebooted or the Break key is used at an inopportune time. Using the Break key to get out of an application that has performed file updates has the same effect as a power interruption if the files are still open. The same holds true for rebooting the system. Many people find out about the Break key or how to reboot the system and then use them to exit whenever they get confused about where they are in an application's menu structure.

Training is an important preventive measure here. The Break key, rebooting, and turning the power off are all relatively harmless when an application is only being used for queries, but they must only be used as a last resort when the application has been used for data entry. It must be made clear when training employees that they should seek help before using any of these three measures in order to avoid reentering data, in addition to the hassles of repairing a damaged file.

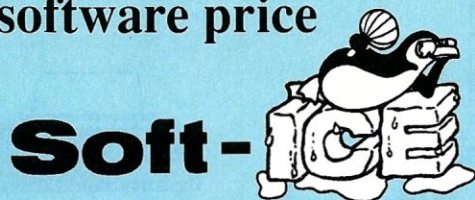
Another related interruption, which is much less frequent where hard disks are common, is for a user running an application directly from a floppy diskette to remove the diskette while the files are still open. This is harmless as long as the diskette is inserted again and the application is given the opportunity to close the file; another point where training is essential. This problem may once again come to prominence as removable mass storage media become more widely used within the next few years.

Media Failures

There are a number of problems that can occur with magnetic media over a period of time. The keyboard, mouse, and disk drives are the only components of the typical computer system that contain moving parts. The moving parts on a disk drive will gradually move out of alignment. This is a normal occurrence in the lifetime of any mechanical device. A certain tolerance for this normal

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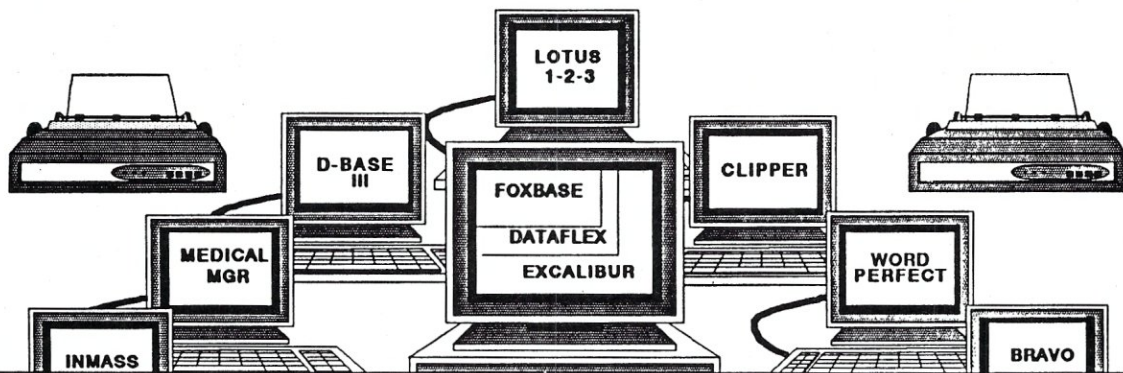
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wear and tear is designed into the drive, but eventually the drive will wear beyond the design tolerances and that's when trouble begins.

This particular brand of trouble takes the form of the read/write heads moving just enough out of alignment to start positioning over the unused space between cylinders instead of directly over the cylinders containing data. Initially, this will only occur for certain cylinders, resulting in the sectors on such cylinders becoming unreadable.

The disk itself also will experience small changes in shape, especially in the case of hard drives that spend most of their time rotating at high speed. These minute changes in shape will have the same net effect as the head movement, causing degradation beyond the tolerance ranges, and certain sectors will become unreadable.

Finally, the thin layer of magnetic material that covers the disk may have tiny faults in it which, over time, make it impossible for that small section to dependably hold a magnetic field.

All of these factors ultimately result in media failures that take the form of unusable disk sectors.

Unusable Disk Sectors

Magnetic media failures result in particular disk sectors becoming unreadable. If the sector that becomes unreadable happens to be one that was already allocated by the system, some form of data loss will result. When the sector is one that contains some of the operating system's control information, a catastrophic loss of data can result.

Magnetic media failures occur as a gradual degradation over a period of time and so are both detectable and avoidable. The operating system will retry both reads and writes multiple times before notifying the user that the operation has failed. In most cases, the user is unaware that the operating system is retrying disk operations, but in some cases, a user familiar with a machine may notice that it has become slower as it has gotten older. This slowdown is due to the operating system having to retry operations much more frequently as the disk ages.

There are products currently on the market, such as SpinRite from Gibson Research and Disk Technician from Prime Solutions, that address this problem (see the "Comparing Hard-Disk Recovery Software" and "In The Public Domain" on page 66). These software packages perform preventive maintenance automatically for your hard disk drive. Each package will perform tests on every single sector of your hard drive, looking for sectors that are offering marginal performance. They will either reformat individual sectors that are failing (which effectively avoids data loss due to alignment or shape-changing problems) or map the sector as permanently unavailable and move the data contained in those sectors to a different sector on the disk (a history of reformat is kept to decide when to give up on a sector). Since these products offer preventive medicine only for the media failure class of problems, they are intended to be used periodically, in addition to normal backup procedures. To give you some idea of what's involved here, on my 44-megabyte disk, which is 1½ years old, Disk Technician performed reformat on 154 sectors (77 kilobytes), and permanently mapped out four sectors (2 kilobytes).

Recovery Techniques

The techniques for repairing a file that has been damaged depend to a large extent on where in the file system the damage occurs. A file may contain header records in addition to data records. It may also have either external or internal indices associated with it. A file also has control information associated with it that is owned and manipulated by the operating system.

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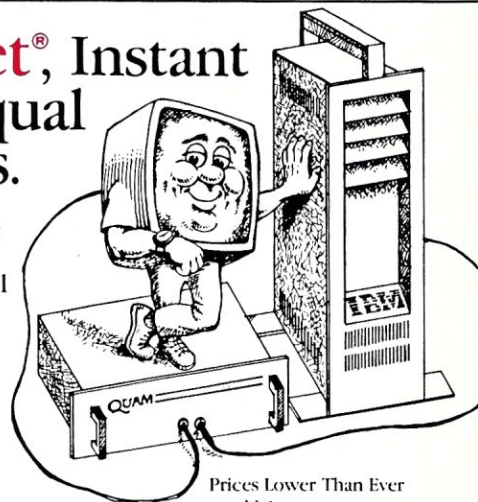


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Each of these information segments requires different methods of handling and presents different challenges to effect a repair.

Header Record Damage

All files do not necessarily contain header records; however, the files used in many database systems do. The header records contain descriptive information that applies to the file as a whole, including such items as the current size of the file in records, the total length of the file in bytes, the owner ID of a file-wide lock, the version number of the software that created the file, and dates corresponding to the last time various events occurred, (e.g., record creation, index creation, modification, etc.). In the case of files consisting of a single record type, you might expect to find the maximum length of the record (variable-length records are sometimes supported), the number of fields contained in the record, and possibly a set of records describing each field.

The key considerations out of all these are the number of records in the file and/or the total length of the file in bytes. Most of the other header data is either constant after the file is created or not essential (the next time the appropriate events occur, the date fields will be corrected anyway). It will be the length of the file, either in records or in bytes, which will be out of sync as a result of lost buffers. This will manifest itself as the last records, those records appended before the lost buffer event, appearing lost or inaccessible.

Once a length field in a header is out of sync, there are a number of ways to recover it, most of which require knowing the location of the length field in the file. The most elegant and reliable method is to create a utility that performs the correction. The calculation is simple. Take the total length of the file as given by the operating system, subtract the total length of the header information, divide the result by the length of a single record, and plug the result into the length field. Such a utility can be written in any number of compiled programming languages, but database languages and application macro languages usually don't have the necessary low-level facilities to do it.

Preventive Measures

As you've already gathered from the discussion in this article, there are any number of risk management decisions to be made, as well as preventive measures that can be implemented to prevent network data from being lost. Here is a summary of these preventive steps:

- If your power is unreliable, get a UPS.
- Don't string power cords across walkways.
- Train users to properly exit applications.
- Train against indiscriminate use of the break key and rebooting.
- Develop procedures for handling these events before they happen.
- Follow a religious backup regimen.
- Incorporate CHKDSK in AUTOEXEC.BAT.
- Make periodic use of disk optimization software.
- Make disk diagnostic software part of your backup procedure.
- Acquire the file structures for the software you use.
- Build recovery utilities before they are needed.
- Have available a copy of something like Norton Utilities to facilitate recovery.

Then there is the direct approach. A copy of something like Norton Utilities and hexadecimal arithmetic can do it for you. Perform the length calculation by hand (or calculator) and then use the data block editing function of Norton Utilities to place a hexadecimal patch in the file. When using this approach the main thing to remember is that hexadecimal numbers are stored in a backward order because of the way that the Intel microprocessor chips access them. Thus, if you calculate that there should be 520 records in the file, this would be 0208 as a two-byte hexadecimal number; however, you would store it in the order 08 02. Four-byte numbers are even more convoluted. For this reason, it is best to have a programmer code and debug the necessary routine before it is needed.

Data Record Damage

Data record damage can be one of the simplest problems from which to recover. A lot depends on what kind of control information is placed in the data records. This is, as usual, different for each application. The worst case is where the file is organized using a linked list type of structure. In this case, the data records will contain pointers to other records in the file. This type of structure is used to dynamically reuse the space that was occupied by records that were subsequently deleted. These pointer chains save space, but in a buffer loss or write interrupt situation, you are faced with the prospect of having to repair the inter-record pointer chains in addition to everything else. It is usually not worthwhile to attempt this. The repairs would have to be made to multiple data blocks, probably spread throughout the file with a good deal of hexadecimal arithmetic involved. The odds of getting it all right are against you.

From a repair point of view, the ideal situation would be where each record is independent of all the other records. The problem becomes one of identifying which record has the problem. The easiest way to do this is to write a program that reads each record and displays a count on the screen. When the program bombs on a damaged record, the count tells you its position in the file. The trick for performing the repair depends on whether your database has a Copy and Goto Record command. Copy the records prior to the first damaged record to a new file, position to the first record following the damage, and copy the rest of the damaged file to the new file. Using this procedure, you only lose a data block worth of records.

In some cases, an end-of-file marker will be placed in the middle of an ASCII text file. This causes messages such as "Unexpected End of File" or "Records Beyond End of File" to be displayed. In this situation, use a program that displays the record count to find the problem record again, then use Norton Utilities to edit the block containing the erroneous end-of-file marker (a single Control-Z character) and change it to a blank.

The most insidious form of data record damage is where a write interrupt occurs in such a way that a garbage value is inserted into a data field. The application will normally not detect the error. The problem is very simple to correct once it has been noticed since the record is still addressable and the application can be used to make the correction. The real challenge is detecting the garbage that has been inserted. In an accounting system, such detection is usually feasible because of the double-entry nature of the system. In a system lacking this type of crosschecking in the data, the problem may go unnoticed for quite some time.

File System Damage

The most serious damage to attempt to repair is damage

to the underlying operating system's file system records. The operating system maintains records in the form of directory entries about files and objects, and the File Allocation Table (FAT) tells which data blocks are in use by files. When these records are damaged, it requires familiarity with DOS internals and Norton Utilities to make the repairs. Here, again, given the complexity of the task, the time it will consume, and the high probability of failure, you are better off restoring from your latest backup and beginning the process of reentering the data immediately.

To look for this kind of file system damage, try running the DOS CHKDSK command as soon as you boot the system. The CHKDSK will detect and correct certain file system problems. Some of the disk optimization utilities can also detect and/or correct some of these problems. Disk Optimizer from SoftLogic Solutions is one such software package. It is not an entirely bad idea to insert CHKDSK in your AUTOEXEC.BAT file to detect this kind of damage, which can also occur in buffer loss situations. It is also a good idea to run the Disk Optimizer type packages to detect some of the problems CHKDSK misses and to prevent disk fragmentation from hurting system performance. Mace Utilities also offers a utility that can be inserted in AUTOEXEC.BAT to back up the FAT.

The File Is Locked Out

One of the less pleasant aspects of operating in a LAN environment is that a file can be left in a "locked" state as the result of a write interruption. This situation occurs when the operating system sets a file level lock on a file, but is interrupted before it has the chance to remove it. It's highly probable that if this occurs, header, data record, or file system damage has also occurred.

The way to unlock a record varies a little from network to network, but invariably, bringing the network "down" and restarting it will clear the locking portion of the problem.

Index Damage

When the file system tells you that a record is inaccessible, especially in the case of a media failure, one of the first things to look at is whether that particular file is indexed. Before resorting to more exotic methods, it is often worthwhile to re-index the file. In a media failure situation, if the failed sector contained index data, re-indexing will solve the problem entirely. In the case of damage caused by an interruption, removing the indices is a good first step since the index is likely to be damaged as well and re-indexing a damaged file doesn't make sense until after it is repaired. All an index can do while the file is still damaged is get in the way of repairs.

Conclusion

Some of the procedures outlined here should be included in the documentation that comes with any software. Software documentation also should include all file structures. This would give the information necessary to attempt repairs in most cases.

Integrity checkers and file reconstruction utilities or procedures are supported by only a few developers, but they can be valuable resources for data recovery. An integrity checker is a utility that performs crosschecks on the data in a file and reports any inconsistencies that are found. A simple example of an integrity checker would be a variation of the length-correcting utility described in the header records section. If the utility was modified to calculate the length, compare the calculation to the length in the header, and display a message if the two did not match, that would be an example of an integrity checker.

The length-correcting utility described in the file header records section is an example of a file reconstruction utility (FRU). An FRU is different from an integrity checker in that it uses the information contained in the file to both detect and correct inconsistencies. The odds of this working are clearly better if the file contains only a few damaged data records. If the file is extensively damaged, an FRU will not be able to decide which information is valid and should be used for reconstruction. In any event, only proven corrections, like the file-length calculation, should be entrusted to an automatic utility.

Application customers can make their recovery efforts easier by telling software vendors they want integrity checkers, reconstruction utilities, and reconstruction procedures included in the documentation. If they comply, the cost of these items would naturally be passed on by the vendors, but how many hours of keystroking would that pay for? And the last time one of your files had to be repaired, how many dollars worth of staff time did *that* cost? □

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Using Online Transaction Logging To Improve LAN Fault Tolerance

The new NEX/OS operating system provides online transaction logging to record information between backups.

by Tim Scholz and Mark Swanson

As local area networks (LANs) evolve and networks become more popular for data-intensive applications, their complexity increases, which creates new opportunities for error as well as data management. And with LANs appearing more frequently in "mission critical" applications, the system must be "up and running" at all times; data integrity must be preserved; and the system must be able to recover data following a network server failure.

Further, heavier network traffic and greater file sizes mean there is more data to protect. All LAN managers must protect network data through periodic server backup to disk, streaming tape, optical disc, or some other data storage format. There are other methods of interim backup currently available, such as disk mirroring and duplicate servers. Both of these methods offer hardware solutions to the backup problem, but both require additional purchases of costly equipment. On the other hand, creating a method to track changes in network data to supplement a complete disk image backup function can make more effective use of an existing streaming tape sub-system in the file server.

Both authors are affiliated with DSC Nestar — Tim Scholz is NEX/OS Product Manager and Mark Swanson is a Software Engineer in Research and Development.

This combined hardware/software approach is what we at DSC Communications Corporation have incorporated into our NEX/OS network file servers. We call the technique online transaction logging.

Supplementing System Backup

Of course, total system backup is an essential part of network management; it is crucial to protect the data on a network server. Although you do have a bit-for-bit image of the network at the time of the last backup, how do you protect data added to the network server between backups? A stored image of the server's disk drive can be used to restore data to recover from a server disk failure, without requiring the re-creation of the operating system, user accounts, and data security information. However, an image backup will only restore the data as it appeared at the end of the last full backup session.

Transaction logging works in conjunction with total system backup to provide incremental information storage of critical data files between total backup sessions. Whereas online transaction logging stores data related to a specific transaction only, it is dynamically linked to the total backup record that contains complete file information. Such an online transaction logging feature gives additional data fault tolerance because it provides a method of updating selected data files to the point of system failure.

During online transaction logging, all changes to files designated by the network manager are automatically written to a streaming cartridge tape concurrently with the updating of the server's hard disk. These processes are transparent to users and, since only updated portions of selected files are recorded, tape use is minimized.

Various versions of tape backup have been available as a personal computer add-on for some time, but the concept has been introduced in LANs as an additional function only recently. Unlike most tape backup systems that are designed to store data when the file is not in use, this network transaction logging function occurs in real time so there is no need to exit from any files.

How Transaction Logging Works

The transaction logging function is managed by an operating system sub-program and requires no special utilities. It is one of many interleaved tasks performed on the file server within the multitasking LAN environment.

Transaction logging is initiated by setting a special attribute within a file. When set by the network manager using file attribute utilities, the logging option appears on screen with other access rights and file characteristics (e.g., read only, write, etc.). When a file is initially created, the transaction logging attribute is set at "off" in default mode. The network

manager activates selected attributes with a keyboard command from a system utility. Figure 1 shows examples of various attribute choices.

In general, logging is advised for important, multiple user files that are critical to the company's operation. For example, data files associated with a database application or accounting system should be tagged for a transaction log record or an important spreadsheet that is always being used. Perhaps all files with a .DAT extension should be targeted for transaction logging.

As each file update is being processed by the server, the online transaction logging sub-program searches for the logging attribute and initiates the process as appropriate. At the beginning of the transaction, the operating system creates a transaction buffer to store the update information. At the completion of the transaction, this buffer is closed, and the data is transferred to the server hard disk and server tape sub-system for transaction logging. If the transaction is not completed, the update is not written to tape. Figure 2 shows the flow of data from the application to the server sub-systems after completion of a transaction.

The Data Storage Medium

While a standard, quarter-inch, 60-megabyte streaming tape cartridge can be used for either total image backup or online transaction logging, each tape is configured differently

according to how its to be used.

For conventional total image backup, the system does not require formatting of data tapes. During total image backup, standard file headers are written to tape, as the backup occurs. As with any total backup routine, all users must be logged off the server, and be taken off line and the server must be rebooted as a local DOS machine before the image backup utilities can be used. This can easily be accomplished using a 5 1/4-inch floppy disk drive installed on the server.

Transaction logging tapes, on the other hand, must be prepared using a special tape preparation utility in-

cluded with NEX/OS. During this process, the tape is erased and a header is created containing the date, time, and other messages if desired, which identifies it as a transaction logging tape.

When preparing a logging tape, the network manager can determine the tape's lifetime. In this way, if any attempt is made to re-use the tape before a specified time, a warning message will be displayed on-screen. Since most transactions average less than 500 bytes, changing the online backup tapes every day or every other day is usually sufficient.

Completed logging tapes will contain the header, plus a single inter-

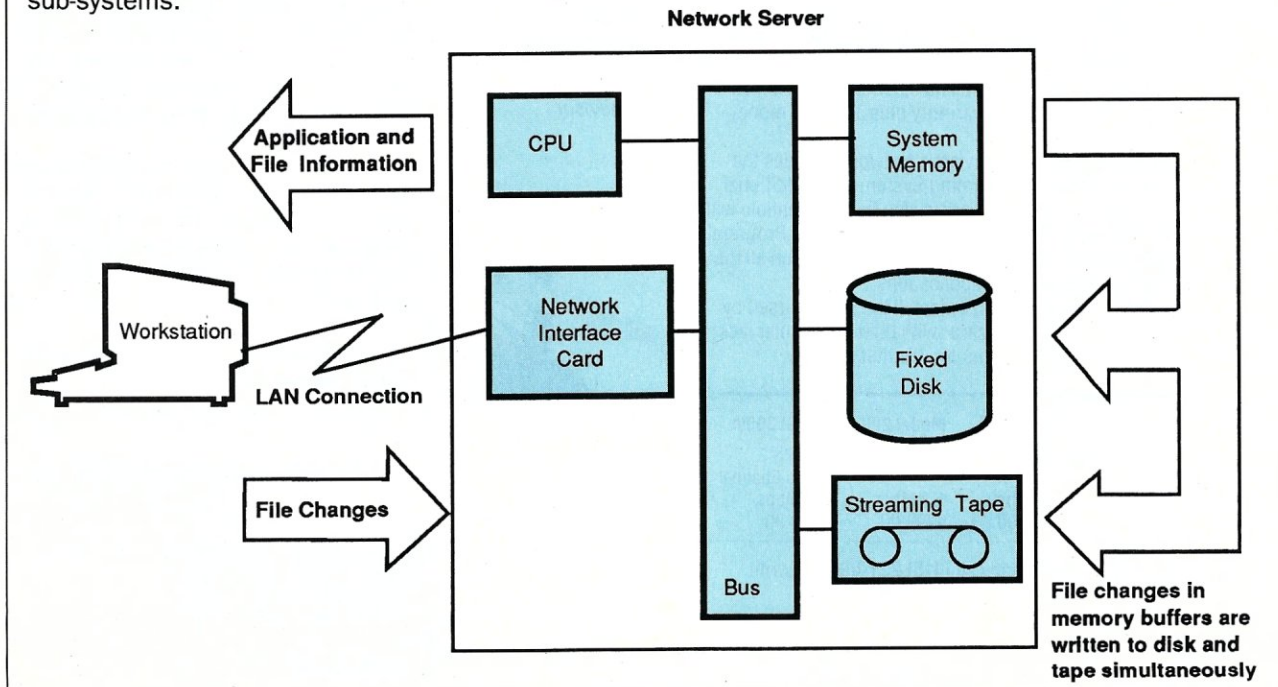
Figure 1. Attribute choices for transaction logging.

File setup mode

File name :	CKEY	Owner :	JOYCE	Type :	<SEQ>
Private flag	[ON]			[OFF]	
Secure flag	[ON]			[OFF]	
Log flag	[ON]			[OFF]	
Share flag	[ON]			[OFF]	
Group : Read	[ON]			[OFF]	
Group : Update	[ON]			[OFF]	
Group : Insert	[ON]			[OFF]	
Group : Delete	[ON]			[OFF]	
World : Read	[ON]			[OFF]	
World : Update	[ON]			[OFF]	
World : Insert	[ON]			[OFF]	
World : Delete	[ON]			[OFF]	
Owner : Change	[NO]			[YES]	
Trustee : Change	[NO]			[YES]	

= Select flag. <- = Flag ON. -> = Flag OFF. <CR> = Exit setup.

Figure 2. A diagram of the flow of data from the application to the server sub-systems.



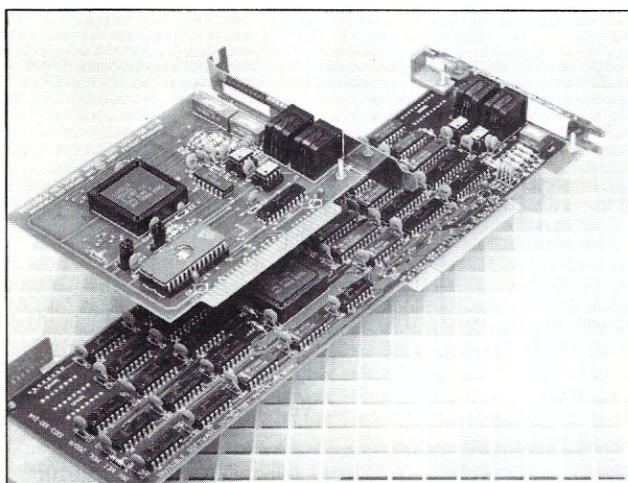
record gap (IRG) that separates the header record from the subsequent data record. The data record itself is a continuous data stream with no IRGs, and file locations are embedded in the data stream as part of the record. This method of data capture and storage is faster and more efficient because it uses less space on the storage tape. The data can be restored by using the appropriate NEX/OS routine, which distinguishes the actual data from file locations during restoration.

In order for online transaction logging to function properly:

1. A properly prepared tape must

be installed in the server when booting with the network operating system.

2. Files selected for logging must retain the same name at all times. This is particularly important to remember since many word processing software products operate on the basis of "temporary files" that are renamed as users exit the program. The operating system will not detect these as updates, since the same file name is not being reused. The NEX/OS LCOPY command provides a system copy command that works as a switch to mark such temporary files for logging.



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Although more total system memory could be allocated to the tape buffer, it has been determined that 1K is more than adequate for the majority of transactions. There are two reasons for this: First of all, during normal logging, only updated portions of a file are written to tape; hence, the entire file is not stored in buffer memory. Secondly, when a greater load is placed on the system, i.e., during hard-disk restoration, all users must be logged off; therefore, performance degradation and memory limits are not an issue.

During the disk restoration process, each logging tape requires approximately 20 minutes to write to disk. The exact time required will depend on both data transfer rates across the bus, and on the number of transactions on a tape. Although there are no inter-record gaps separating the transactions on the logging tapes, each transaction's disk location data must still be read and acted on. Therefore, a large batch of data will clear the restoration process more quickly than many small transactions.

Conclusion

Online transaction logging enhances data fault tolerance between backups while permitting network users to continue their work. And, since an existing tape drive is used for the process, there is no additional hardware expense. As an automatic function of the system, it is less cumbersome and more efficient.

As a software solution, online transaction logging represents a new approach to solving the emerging requirements for data integrity in a LAN environment. It is both cost-effective and responsive to user needs. □

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	Bluestreak Plus Communications (two ports, programmer's interface, terminal emulation)	\$400
	CQL Query System (SQL retrievals plus windows)	\$325
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	Greenleaf Data Windows (windows, menus, data entry, interactive form design)	\$220
	Greenleaf Communications Library (interrupt mode, modem control, XON-XOFF)	\$175
	TurboTeX (TRIP certified; HP, PS, dot drivers; CM fonts; LaTeX)	\$170
NEW!	Sherlock (C debugging aid)	\$170
	Essential resident C (TSRify C programs, DOS shared libraries)	\$165
	Greenleaf Functions (296 useful C functions, all DOS services)	\$160
	Essential C Utility Library (400 useful C functions)	\$160
	Essential Communications Library (C functions for RS-232-based communication systems)	\$160
	WKS Library Version 2.0 (C program interface to Lotus 1-2-3, dBase, Supercalc 4, Quatro, & Clipper)	\$155
	OS/88 (U*x-like operating system, many tools, cross-development from MS-DOS)	\$150
	ME Version 2.0 (programmer's editor with C-like macro language by Magma Software; Version 1.31 still \$75)	\$140
	Turbo G Graphics Library (all popular adapters, hidden line removal)	\$135
	Vmem/C (virtual memory manager; least-recently used pager; dynamic expansion of swap file)	\$130
	TurboGeometry (library of routines for computational geometry)	\$125
	CBTree (B+tree ISAM driver, multiple variable-length keys)	\$115
	Minix Operating System (U*x-like operating system, includes manual)	\$105
	PC/IP (CMU/MIT TCP/IP implementation for PCs)	\$100
NEW!	B-Tree Library & ISAM Driver (file system utilities by Softfocus)	\$100
	Tele Operating System (TeleKernel, TeleWindows, TeleFile, & TeleBTree by Ken Berry)	\$100
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The Archive Librarian: An Archival Strategy for System Backup

by Lori Birchall

There are a variety of approaches to data backup management, ranging from a weekly full checkpoint to more effective, automatic approaches such as the data librarian.

When it comes to hard disk backup, everyone has a horror story to tell. Back-up problems range from accidentally deleted files to hard disk crashes to backup tapes destroyed by fire.

Most end-users take system backup for granted. And, unfortunately, only after data disaster strikes do they appreciate the importance of proper backup management. That's why they come to you—the PC network professional—to effectively protect their valuable data in a simple and organized manner.

As network professionals, you know that the only practical hardware for serious PC backup is a tape drive. However, according to both the 1987 *Disk Trend Report* and *Peripheral Strategies' 1988 Low End Tape Drive Market Strategy Report*, only 12 percent of all high-capacity disk drive owners have tape drives. Of course, merely buying a tape drive is not going to solve data protection

problems. It's the backup management software that makes the difference.

First, let's take a look at the most common backup strategies.

Strategy 1. Weekly Full Checkpoint

Five tapes are used in this backup strategy, one for each day. On Friday, a Full Checkpoint (copying all files to tape) is performed to a tape named "Friday" (Figure 1). This usually takes 30–45 minutes to complete, but it's only done once a week. On Monday through Thursday, Modified Checkpoints (copying all files that have changed since the last backup) are performed. This backup scheme ensures that if the hard disk or server ever crashes, it can be restored to the way it was the previous night.

Simplicity is the primary advantage of the Weekly Full Checkpoint method. However, most users need to keep their files for longer than a week. There's also only one Full Checkpoint tape, so if a fire ever swept through an office that used this data protection technique, the tapes would melt along with the computers.

Strategy 2. Sequential Reuse

This strategy resembles the method described above except that instead of one Full Checkpoint tape there are several, e.g., A1, B1, C1, D1, and E1. These tapes are used in sequence every Friday, expanding the horizon from one week to five weeks (Figure 2). Horizon is the length of time backup files exist before reuse.

When one Full Checkpoint tape is in use, the others are protected in the vault. For example, if it becomes necessary to retrieve a file the way it existed four weeks ago, the old tape is still available. If the file was changed more than five weeks ago, however, the old version is beyond the horizon and has already been overwritten.

Strategy 3. The Tower of Hanoi Rotation System

The Tower of Hanoi exponential rotation scheme helps network administrators who want to expand their tape horizon. Named after a child's mathematical puzzle, the Tower of Hanoi uses some of its tapes frequently, some less often, and a few very seldom (Figure 3a). This is a common technique used for mainframe backup. For five tapes, the sequence looks like this:

ABACABADABACABAE

Lori Birchall is a market analyst for Palindrome Corporation, a manufacturer of data library systems, and an Indianapolis-based freelance writer.

The primary advantage of this technique is that it provides long-term protection without using a large number of tapes. At any given moment, there are an abundance of recent Checkpoints, a variety of old Checkpoints, and several ancient Checkpoints spread throughout the tapes. Each week, some of the tapes are rotated to and from the vault, ensuring that there are tapes in the vault at all times for protection against fire and theft (Figures 3b and 3c).

If it becomes necessary to undo changes to a file, there may be as many as nine Checkpoints to choose from: one for each day of the prior week; one for last Friday; one for the Friday before that; and three older versions that are approximately four, eight, and 16 weeks old.

Thus, the horizon is extended. Sixteen weeks may seem like a long time, but some files are milestones. A user may want to refer back to these files months or years after they've changed.

Strategy 4. Combined Checkpoint-and-Save

Every system has some files that should never be overwritten. The Combined Checkpoint-and-Save method uses Monday - Thursday and A1 - E1 tapes in the same way as the Tower of Hanoi technique. In addition, a Save tape is mounted once a month to permanently save all files from the prior month (Figure 4). Save tapes are never overwritten. On November 21, for example, all files that

Figure 1. The weekly Full Checkpoint is the simplest backup strategy, and the most primitive. Data is stored on one Full Checkpoint tape for one week, so stored data is lost after a week.

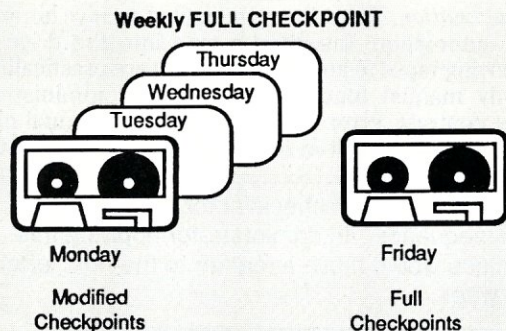
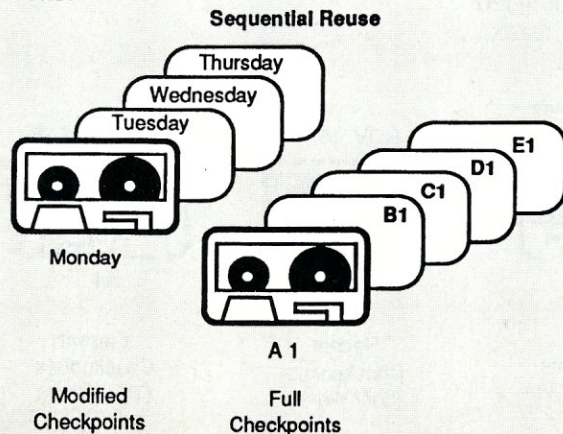
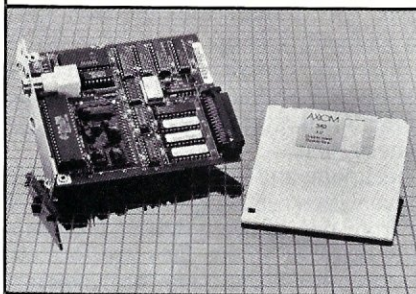


Figure 2. With Sequential Reuse, there are five Full Checkpoint tapes, one used every Friday in sequence. This expands the backup horizon to five weeks.



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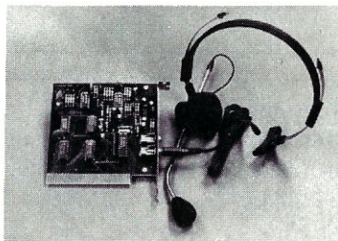
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were last modified from October 1 to October 31 are appended to the end of the Save tape. These files are recent and stable. The administrator can also explicitly save any files that have reached a milestone.

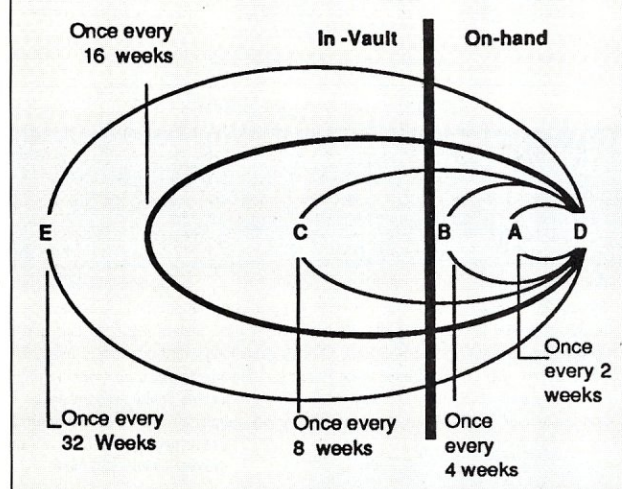
The administrator saves only a small fraction of the hard disk or user area each month, thus the Save tape grows slowly. When S2 finally fills up, a new tape, S3, is added. To compare the current version of a file to the way it was before the last major revision, there is likely to be a Saved copy even if that file is a year old. The horizon for this technique becomes infinite.

The Combined Checkpoint-and-Save method creates a comprehensive archive with a relatively small number of tapes, but it suffers from one of the toughest problems of archiving: keeping track of where files are located. When you want to find a copy of a file, it may be necessary to spin a dozen tapes to locate it. Even if you know when the file was created, it still may be necessary to look at several tapes. Given a choice, it's preferable to look at all the available versions at the same time.

The Network Administrator

To illustrate the problem, let us consider the case of Bob, a Network Administrator for a medium-sized corporation, who uses the Combined Checkpoint-and-Save technique. Every day, he backs up the 140-MB file server to tape.

Figure 3a. A graphic representation of tape orbits offered by the Tower of Hanoi rotation sequence. Tape D is being used this week.



Because the server's hard disk holds more data than any single tape, Bob has multiple tapes per backup tapeset.

Bob has a seemingly impossible responsibility. He must keep the file server from running out of space, yet he doesn't have the tools to effectively do the job. Bob often asks users to clean up their files, but many don't follow through. As a result, he often must determine which files are important and which are unimportant.

Bob has another problem. Users frequently request file retrievals. There is such a massive quantity of tapes and files that an on-line catalog is essential to organize the tape library. With an on-line catalog that knows the location of every version of every file, Bob can find all of the versions available without spinning a single tape.

Up until now, the Combined Checkpoint-and-Save method was the best way to protect files. The price to pay for protection, though, is the cost in extra time needed to manually perform the backup functions and keep the tapes organized. The larger the hard disk or file server, the more time has to be given to the backup scheme. Even with all of its complexity, the Combined Checkpoint-and-Save method has only one permanent Save copy of most files. If that tape is ever lost or broken, the only copy of those files is gone.

Enter the Archive Librarian

The archive librarian represents a new generation of mass-storage software that is fully automated. Mainframe and minicomputer systems have been using archive librarians for the past several years, and archive librarians are now becoming available for PCs.

There are several characteristic advantages common to all archive librarians:

1. **Automation.** The primary benefit of archive librarians is automation. Inserting a tape into the drive and moving tapes to and from the vault are practically the only manual functions left for the administrator. By contrast, errors encountered with manual methods usually result in lost files. The lost files usually

Figure 3b. A typical checklist for the Tower of Hanoi sequence. An administrator applying this technique would move a marker to the next letter each week.

A B A C A B A D A B A C A B A E

Figure 3c. Data coverage after 16 weeks. Note that the backup administrator has already progressed through the sequence outlined in Figure 3b and is about to begin the sequence again. Next week, Tape E will be used for backup for the first time in 16 weeks.

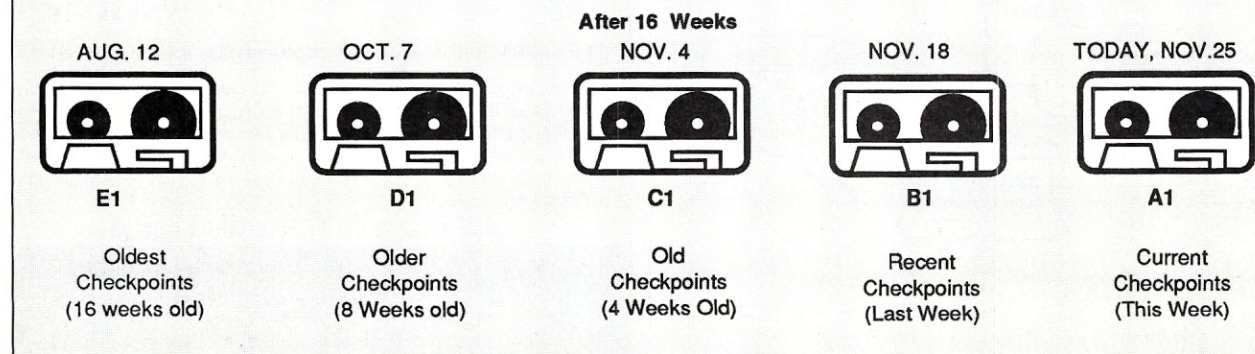
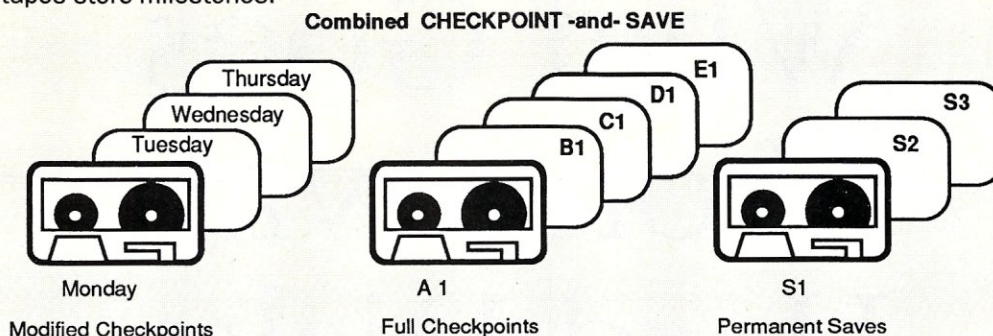


Figure 4. The Combined Checkpoint-and-Save method, one of the most effective approaches to data protection, uses the Tower of Hanoi rotation sequence and separate Save tapes. The Modified and Full Checkpoint tapes back up fast moving files and recent changes, and the Save tapes store milestones.



have to be reconstructed and then double-checked for accuracy. Users who have to retrieve files from manually stored archives are often near panic and redoing work adds to the frustration. It is unscheduled and unmanaged time spent during the height of deadlines, and you end up paying for it in morale as much as in time and labor.

2. **Integrated Checkpoints and Saves.** Archive librarians integrate Checkpoints and Saves onto the same tape. Checkpoints are copied to a reusable section of the tape separate from the Saves. A typical archive would have three Save copies—a reasonable number for fully protected files—on three different tapes. Once a file has been copied to three different tapes, the librarian does not waste tape space with extra copies.

Full Checkpoints are notorious for loading tapes with unnecessary copies. In its place, an archive librarian uses Incremental Checkpoints. An Incremental Checkpoint is much faster than a Full Checkpoint because it only copies the files that are not fully protected. A good archive librarian will also use Modified Checkpoints. A Modified Checkpoint only copies the files that have changed since the last backup and may only take two or three minutes to complete.

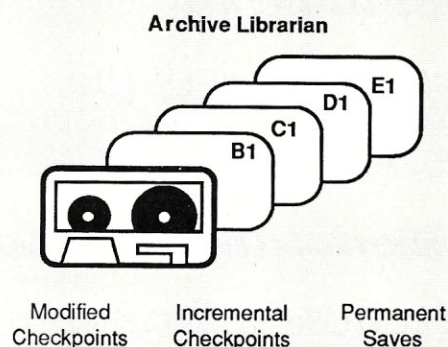
3. **Full Protection From Disasters.** An archive librarian continuously ensures that a complete and relatively recent set of tapes is created for off-site storage. Tapes are rotated once each week, even if the current tape is nearly empty. The librarian decides which tapes make up a complete set and tells the administrator which tapes to move to and from the vault. To do this, the librarian needs three copies of most files. At least one copy is on-site, one is in the vault, and another is in transit either to or from the vault (Figure 5).

4. **Simple Retrievals.** Looking for a specific file version to retrieve has always been a hassle because no one knows which tape holds the version that was saved. An archive librarian makes file retrievals easy for two reasons:

First, the history of every file is stored in an On-Line Catalog. The automated catalog allows the administrator to easily see all versions of the files and request retrievals by tagging the files directly in the catalog.

Secondly, there are three Save copies on three different tapes. After the files for retrieval have been identified, the librarian will list the tapes that contain the desired files. All the administrator has to do is

Figure 5. Checkpoints and Saves are stored on the same tape using the automated data librarian. Full Checkpoints are replaced with Incremental Checkpoints and Modified Checkpoints. With the data librarian, the same amount of information that was stored on 12 tapes in the Combined Checkpoint-and-Save technique is stored on five tapes.



insert one of the listed tapes into the tape drive. The librarian gets as many files as it can off of that tape. If there are still files left to retrieve, a revised list of tapes will appear on the screen.

5. **Dormant File Identification.** Archive librarians know when a file hasn't been used in a while. A dormant file is one that has not been read, written, or executed for a long time. When the librarian finds a dormant file, it can be configured to Migrate the file from hard disk to tape, leaving extra room on the disk for future files.

All network professionals understand that data backup is important. The method you choose for system backup is also important. When it comes to data protection, the method you select should be fast, effective, reliable, and simple. Naturally, backup needs differ with each configuration, so you need to know and understand backup concepts in order to develop successful archiving strategies that suit the needs of the systems you support. □

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What Goes Wrong with Hard Disks

by Grey Staples

This in-depth explanation of the workings of hard-disk systems can help you diagnose information storage problems and recover "lost" data.

This article deals with how data files on PC hard disks can be damaged or rendered inaccessible. The discussion will be purposely kept to a "generic" level of equipment and DOS release. I will not be discussing specific brands of computers, controllers, disks, or utility software.

Grey Staples is the president of Information Repair Service, Inc., of Scottsdale, Arizona. The company specializes in data recovery and repair of damaged files and DOS control areas. Mr. Staples has degrees in physics and electrical engineering, and is a 25-year veteran of the computer industry. He has been granted both Certified Data Processor and Certified Computer Programmer status by the Institute for the Certification of Computer Professionals.

DOS Disk Organization

Figure 1 shows the steps taken by data from the time the operator saves a file to the moment the computer actually stores the bytes on hard-disk media. To begin, the operator asks the application program to write the data file to disk. Some software will hold the entire file in RAM and then proceed to write everything to the hard disk. This is generally true of older spreadsheet and word processor programs. Others only need to access a portion of a file at a time and will buffer blocks of data, reading and writing them dynamically as needed. This group of software may use the DOS buffer pool to hold the data sectors and rely on DOS functions to write them to disk at a later time.

In any case, for the write operation, DOS is requested to locate the data in RAM and begin transferring it to disk, typically using the DOS Write Handle function. File-oriented parameters such as offset within the file are used by a program, and then translated by DOS to physical parameters such as drive, cylinder, head, and sector. Figure 2 shows how a cluster number is translated into a disk address. Next BIOS is told, with interrupt 13, to write a sequence of 512-byte sectors to the disk. Up to this point we have been dealing with application software and DOS. We are now venturing into the controller and disk hardware. Generally, the disk controller is the card that plugs into the system board and is connected by a ribbon cable to the sealed hard-disk unit.

Once the physical location of a sector is defined and presented to BIOS, we encounter the device driver logic. The disk controller must be addressed in its own terms. The driver constructs a command block in RAM, typically 6 bytes in size, and outputs it to the controller through a particular set of port addresses. It is responsible for converting the physical cylinder, head, and sector coordinates into stepping motor commands. Finally, the desired track is found (address mark is detected) and the sector is located (sector preamble). The sector is copied to the magnetic media and the Checksum or Error Correcting Code, computed by the controller, is written. The data is a serial stream of bits directed to the hard-disk unit itself.

All this happens in the span of milliseconds.

Let us step back from the "flight of the data sector" and look at how the hard disk is organized. Figure 3 shows the usual physical layout of a track. Each 512-byte sector is surrounded by gap bytes and preceded by a Preamble or Identification Block, containing cylinder, head, and sector values. As it comes right out of the box from the manufacturer, we usually have an empty disk, and a "low-level format" process is required. Typically, the program to perform this operation is already in the ROM BIOS logic on the controller. If this is the case, the manufacturer's instructions will talk about using the DEBUG utility and executing a particular address. Usually, C800:5 or C800:CCC is used. After the low-level format, the drive is still useless to DOS. All the process did was build the preamble for each sector and create data sectors with a fixed content, usually a hex "F6" character.

Every sector preamble identifies itself with cylinder, head, and sector values. These provide the controller with the ability to recognize any sector. The interleaving of sector numbers is defined during this format. Interleave deals with just how many sectors are skipped between, say, Sector 1 and Sector 2. At issue is how long it takes for the disk to rotate to the next sector, and how long it takes the computer to decide to ask for it. Faster processors result in a smaller interleave factor. An optimal interleave will present the next desired sector just when the computer needs it. A wrong choice will waste the time it takes for a complete revolution of the disk (latency time). Only sequential accesses can be optimized with

our present PC hardware—random requests are on their own. Generally, DOS loads a program by requesting an entire track to read at a time. The controller finds the first sector, transfers it to RAM, and then waits for the next one. Random sector requests are generally presented one at a time. In a multiprogramming system, such as our mainframe cousins, the controller could be buffering multiple sector requests and using a "position sensing" mechanism to optimally select the random sector to read next.

Figure 4 depicts the relationship between the boot sectors and the DOS control areas. The DOS utility *fdisk* is called upon to define the DOS partition. At this point, there are considerations about 32-megabyte (MB) limitations, extended partitions, and ways to overcome the inherent DOS limitations for large drives. Figure 5 shows the sequence of events during the booting process, and the sectors involved. One result of the *fdisk* step is the creation on the Master Boot sector on track 0, sector 1. The boot sector is the first thing read from the disk by the ROM booting process. If this sector is not found, the entire drive is "invalid." It is the responsibility of the Master Boot logic to locate a bootable DOS partition, read the Partition Boot sector, and transfer control to it.

The DOS FORMAT utility prepares the partition by building the Partition Boot sector, and constructs two copies (usually) of the File Allocation Table (FAT), reflecting any unreadable sectors (bad clusters). FORMAT performs a read-only scan of all sectors in the partition,

Figure 1. The steps taken by data in saving a file

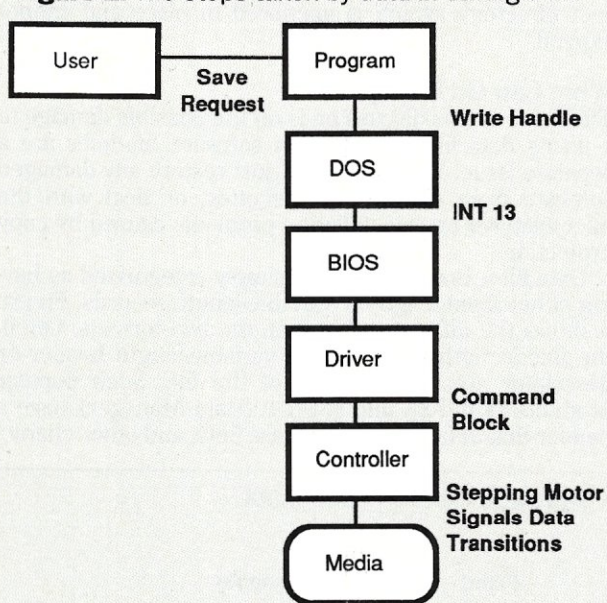


Figure 2. Cluster to Address Translation

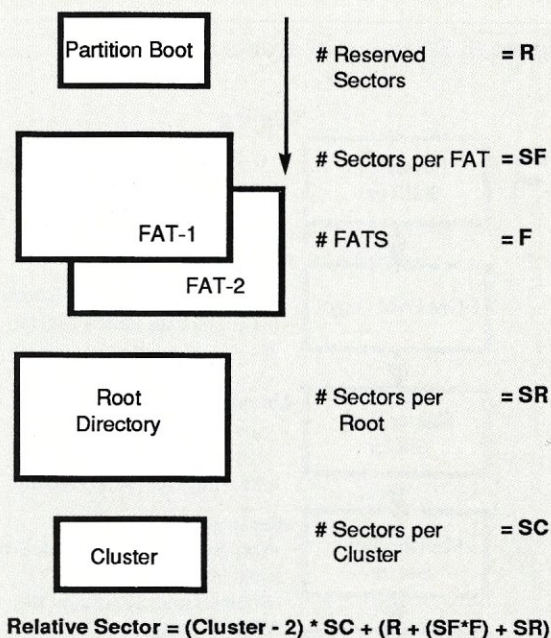
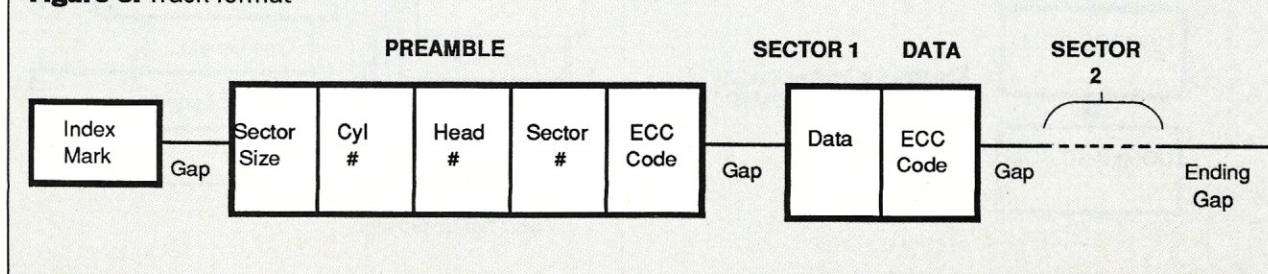


Figure 3. Track format



building a new FAT in memory. All entries in the root directory are cleared by setting the first byte of each 32-byte entry to a hex 0. If the partition is to be bootable, the two hidden files of IBMBIO.COM and IBMDOS.COM

Figure 4. DOS disk layout

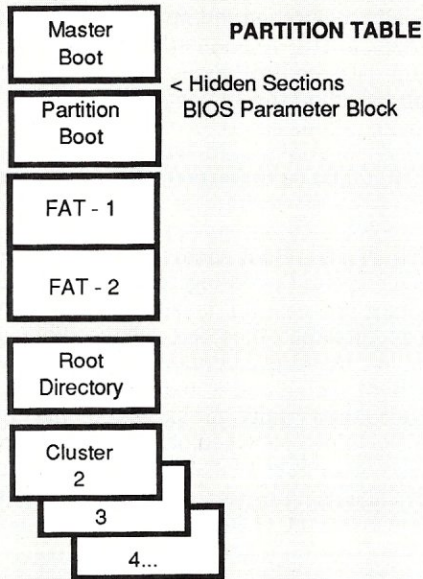
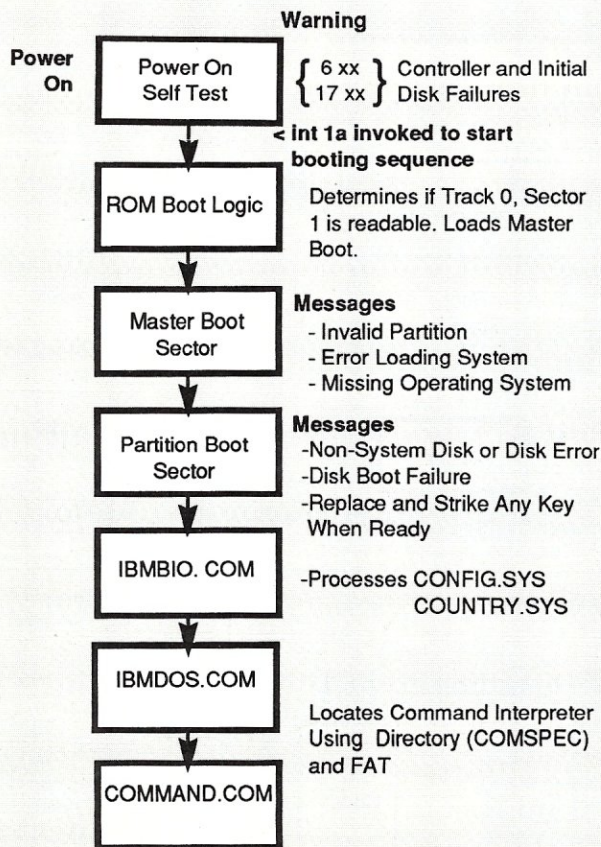


Figure 5. Sequence of events during booting



(in MS-DOS, the files are named IO.SYS and MSDOS.SYS), and the command interpreter, COMMAND.COM, are placed at the beginning of the area of data clusters (starting with cluster 2). IBMBIO.COM and IBMDOS.COM *must* be the next sectors after the FAT and root while COMMAND.COM can be anywhere on the disk. Note that the Boot Sector also contains the BIOS Parameter Block, which defines all the parameters needed by DOS to translate logical, or cluster level, requests into physical parameters suitable for INT 13 requests. These values were used in Figure 2 to perform the cluster to physical address transformation.

The File Allocation Table links one cluster of a file to the next. Each entry can be 12 or 16 bits in length. The Partition Table in the Master Boot sector contains a bit flag designating a 12- or 16-bit FAT format. A 10-MB drive using DOS 2.x versions would have a 12-bit FAT format. Here, we have only eight sectors for the table, and the maximum cluster number is 2500+. An IBM AT with 20 MB that uses DOS 3.x has a 41-sector FAT. Each cluster is 2048 bytes in size, and there are 10,405 clusters. Larger drives require larger FATs, and perhaps larger cluster sizes.

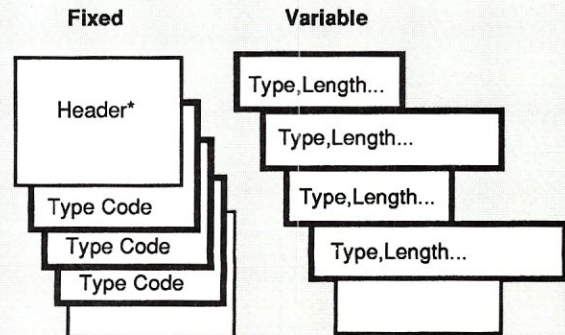
The hard-disk root directory is usually sized at 32 or 64 sectors. Each sector holds 16 entries (of 32 bytes each). For our discussion, the important items are file name and extension (the first 11 bytes of each directory entry), the attribute byte (the next byte after the extension), the starting cluster number, and the file size. Together, these describe the file and where it initially resides. Subdirectories are essentially expandable files with just a directory attribute. Being treated as a file allows the subdirectory to grow to multiple clusters—unlike the root directory, which is anchored in place and cannot expand.

What Can Go Wrong

The focus of this discussion is on the possible damage to a user's data files. Application software modules are a separate issue. You can usually just restore any damaged software from distribution diskettes, or deal with the manufacturer on reinstallation problems caused by copy protection.

Data files, however, can be simply categorized as having either fixed-length or variable-length records. Figure 6 shows the difference between the two formats. Often, the fixed-length variety has a variable-length header or descriptor area at the start of the file. Such popular products as dBASE and SMART (Data Manager) have a header that defines each database field, and other charac-

Figure 6. General file formats



*May not be present

teristics. After the header they get down to a repetition of fixed-length database records. With dBASE, each record is of fixed size, preceded by an active/deleted flag. SMART uses a 2-byte prefix on each record to define the length of the following record, with a high-order bit flag showing active and deleted status. For fixed-length Data Manager files, the length value is the same for each record. A variable-length record format is also available.

Some fixed-length formats are even simpler. I have encountered CAD and database products in which each record is a constant 128 bytes in size. Record type and control flags are generally stored at the beginning of each record.

Variable-length format files typically have record type and length bytes preceding each record. In Lotus 1-2-3, for example, the first two bytes define the record type (least significant byte first) and the next two define the record length, excluding the four control bytes just de-

*With even faster processors
and larger disks,
the operator can now
destroy more data faster
than ever before.*

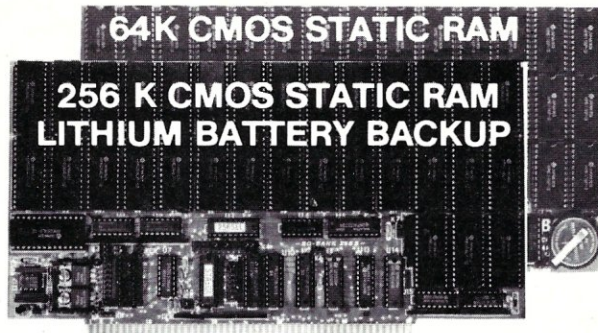
scribed. Files of this format are quite vulnerable to random sector-level corruption. A single misplaced sector in a 1-2-3 file will cause the software to report an error and stop loading the file at that point. The rest of the file is not readable and therefore is lost.

Operator Problems

The first problem area involves the computer operator. The person at the keyboard is quite capable of wreaking havoc on data files (which are usually not sufficiently preserved). With even faster processors and larger disks, the operator can now destroy more data faster than ever before. These operator problems sometimes derive from the simple omission of an important parameter from one of the DOS commands. The action of deleting all the files on a diskette and leaving out the important "A:" will result in *everything* in the current directory (word processor, spreadsheet, database, and so on) being deleted. Out of habit, the DOS question of "Are you sure? (Y/N)" is automatically answered with a yes reply by the operator, who expected to be asked that question anyway.

We now reach for our favorite unerase utility and ask it to "save our bacon." In an erase operation, all the clusters owned by the file are freed (FAT entries set to zero), and the directory entry is flagged with a hex "E5" overlaying the first byte of the file name. The file size and starting cluster number are left intact, allowing the unerase utility to work. With luck, the file may be automatically resurrected and returned to usefulness. On the downside, you may be required to inspect a myriad of clusters, all appearing in some strange Martian-like form; a procedure that demands that you know the intimate details of each file's format. One quickly learns how to identify ASCII

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labels in a spreadsheet, for example, to determine if it is appropriate for any cluster to be included in the file being unerased. Next, you should invoke the application and ask it to validate your selections during the unerase process. Variable-length format software will report an error if any alien clusters or records are encountered. You now find that your 1000-line worksheet is reduced to 100 lines; everything else is not readable. We now get into long hours of trial and error, usually at 3 a.m.

When a user creates or extends a file, DOS has to find space for it. The File Allocation Table provides a list of available clusters, each of which is a candidate to hold the new data sectors. Release 2.x of DOS starts at the lowest cluster, and the first available one (a zero entry in the FAT) is claimed. DOS repeats the process of using the next available cluster until the entire file is saved. This approach creates a good number of file fragments scattered around the disk. The read-write head is repeatedly moved around the disk, slowing down the total file loading

Failing components, misseated controller boards, and "cold" or broken solder joints can cause a variety of problems.

time. In DOS 3.x, the process is refined a bit by starting the search at the current cluster, proceeding upward. The dispersal of fragments is reduced, and less head movement is needed. The degree of file fragmentation can be shown by using the CHKDSK command in any subdirectory. The "*" causes the utility to report any files that are not composed of contiguous clusters, as reflected in the FAT. Routinely running a disk optimizer utility reduces or eliminates fragmentation and tips the odds in your favor for a successful unerase.

An accidental DOS FORMAT operation is essentially an unerase problem in the extreme. As outlined above, the FORMAT program first reads every sector in the partition, looking for errors or unreadable sectors. A new, and empty, copy of the FAT is being constructed, with any bad clusters flagged. The root directory is then subjected to what I call a "super erase." The first byte of every directory entry is reset to a hex 0. DOS uses the zero as a flag to determine when to stop searching a directory. There is no reason to read all 64 sectors in a root directory when only a few sectors are actually being used. The rest of the root is typically untouched. Finally, the new, and empty, FAT is written to the disk. The "Format Complete" message appears. If you ever inadvertently start a FORMAT on your hard disk, the best recourse is to turn the computer off as soon as possible. At best you will terminate the read-only scan of the disk looking for bad sectors. At worst, parts of the root or FATs may be overlaid. It

pays to use a commercial "Unformat" utility if accidental FORMAT of the hard disk is a worry.

It is possible to destroy the first track on a hard disk (Master Boot sector) by the operator's using an XT version of the IBM parking program on an AT. Older versions (1982 and 1983) of the SHIPDISK program on the IBM Diagnostics diskette for the XT have a format function executed on the current track in case an unexpected error is received during the parking process. The AT produces such an error, triggering the XT version to issue an "05" command (format track). Unfortunately, the AT expects interleave to be specified by two registers pointing to a table of sector numbers. The old XT program makes no attempt to set these registers. The result is that track zero is subjected to a low-level format with inappropriate sector numbers. The bottom line is that there is no sector 1, so POST fails for that drive. The AT is told that drive C is not valid. The recovery strategy is to perform a low-level format on track zero using a commercial disk utility, run *fdisk* to rebuild the Master Boot sector, and redefine the partition(s). With luck, the undamaged partition will fall right into place and match the new partition table in the boot sector.

The term "corruption" will be freely used in the rest of this article. Let me offer a definition. In programming circles, we frequently use the words "memory corruption" or "stack corruption." Simply put, some program has written over a sensitive section of RAM with "alien" data. Typically, your program, which depends on an understandable section of memory, will malfunction. Phrases such as "out to lunch" or "off in the weeds" abound to describe what happens. Sometimes you have to turn the computer off to clear the damage from the computer memory. The same problems occur on disks. Sector-level corruption is caused by damaged or "alien" sectors being written to the requested sector. In the following section we will explore how badly things can go wrong.

Software Problems

Software errors are a logical possibility. Since the application program, or the operating system, is making decisions about what data is to be written where, we have the possibility of file and disk corruption. Generally, software products get a clean bill of health. But there are occasional bugs in programs that can damage your data files. Fouling your data is one thing—corrupting the FAT is quite another problem. The following discussion of hardware-induced errors will encompass most of the possible software-caused corruptions as well.

One area of software-induced problems needs to be mentioned. Trojan Horse programs, which masquerade as benign utilities but which are quietly trashing your hard disk, are a malignancy. Corrupting, or clearing the FAT, is equivalent to the effects of a DOS FORMAT, with the advantage that, if the root is still intact, you have an easier job of finding each active file and then unerasing each one. Trashing track 0 is the same as running an old XT SHIPDISK on an AT. Luck might prevail and, if so, the partition will be reinstalled exactly as it was before.

Hardware Problems

Once DOS and BIOS have dispatched a sector to be written to a specific spot, or sector, on the disk, the controller takes over. Hardware malfunctions at this level can be quite insidious. Failing components, misseated controller boards, and "cold" or broken solder joints can cause a variety of problems. Each of these will change the intention of the requested disk write, or read, operation. For example, the controller decided *not* to write one or more sectors. What we then have residing on the disk is the

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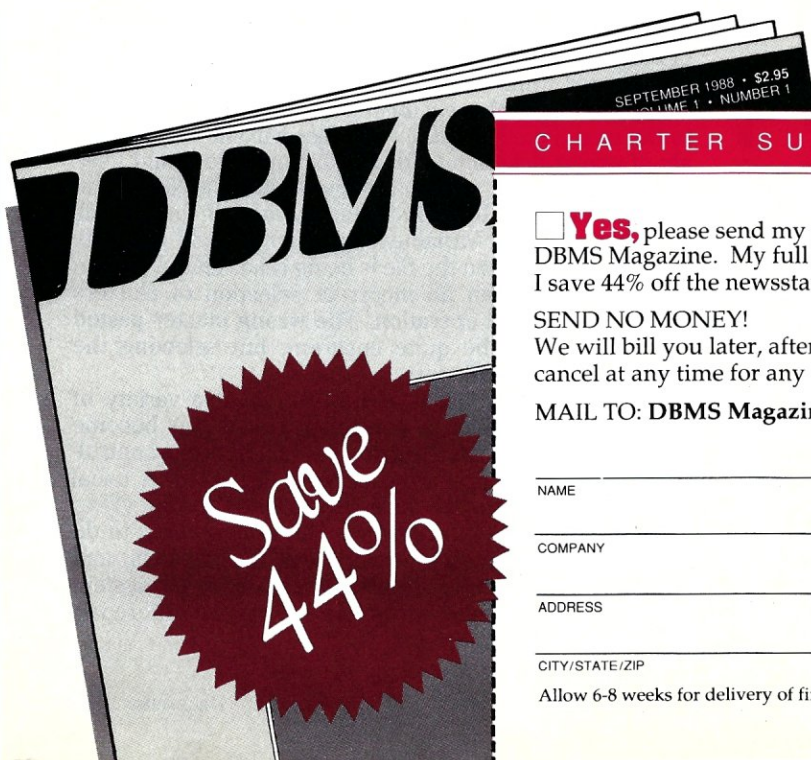
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A more frequent problem is one in which the sector is

Bad electrical contacts are a source of a variety of problems. Sometimes a controller board can become misseated. That is, the electrical contact between controller and the system board has been disrupted. A usual symptom is that the disk fails during POST testing (17xx errors) and refuses to respond. The easiest thing to do is remove the controller card, clean the contacts, and make sure the board is completely reseated in the system board. If this fails, take two aspirin and call the disk repair service in the morning.



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Broken or marginal contacts cause a different problem. When the computer is first powered on, the disk does not respond. A while later the disk can be accessed from a diskette-booted system. A disk testing program shows a large number of defective clusters. After a while, fewer clusters are shown to be bad. Finally, no clusters test bad. The dynamic changes are due to heating effects within the computer, which cause a marginal contact to expand and close, making the defect appear to go away. This is a quite simple analysis of the problem. The recovery strategy is an opportunistic one. When the machine is warm enough to extract all the needed files, back them up and have the disk unit repaired or replaced.

So far I have been discussing failures during the writing of a sector. Read-time errors are even worse. Consider the effect on a program that is innocently requesting a sector to read, if the hardware presents the wrong sector. The software may report the same symptom as caused by a corrupted sector during a prior write. The software may accept the erroneous data and pass it on. For example, BACKUP would be vulnerable to this kind of failure. Your safely backed up files now contain defects. I call this result "Swiss cheese" —lots of holes. An early indication of this problem is when you see strange data that resembles a list of zip codes in the middle of a record in the Name and Address database. Either the sector in the database has been clobbered by a stray sector from the zip code index file, or you are experiencing random read-time errors that are presenting the wrong sector. One interesting controller I encountered would successfully read the Master Boot sector and then produce that same sector on complete tracks elsewhere on the disk. Some tracks were readable; others seemed to contain the same, but illogical, contents for all 17 sectors. There is only one Master Boot sector on a hard disk—not one in each sector of an arbitrary track. It was as if the Master Boot sector got stuck in the controller's buffer.

Figure 7a. Bit loss in a Root Director Sector

This is the way a DOS 3.3 system diskette should look.

```
Volume in drive A has no label
Directory of A:\

IBMBIO  COM      22100   3-18-87  12:00p
IBMDOS  COM      30159   3-17-87  12:00p
COMMAND COM      25307   3-17-87  12:00p
ANSI    SYS       1678   3-17-87  12:00p
APPEND  EXE       5825   3-17-87  12:00p
ATTRIB  EXE       9529   3-17-87  12:00p
BACKUP  COM      31913   3-18-87  12:00p
BASIC   COM       1063   3-17-87  12:00p
BASICA  COM      36403   3-17-87  12:00p
*more*
```

Warnings

Some of the more insidious disk failures are preceded by some fairly obscure warning signs. One symptom is the "I'm sure I changed that data" syndrome. Here the controller may be deciding not to write some updates back to the disk. Preserve your backups and keep an eye open for future anomalies. The intermittent update problem could be a cause of "cross-linked" files, as reported by CHKDSK. Consider that if FAT sectors are not being updated, then the next time DOS needs a free cluster it will retrieve an incorrect version of a FAT sector. The result is that two files now share the same cluster.

In Conclusion

Admittedly, this article is highly subjective in that the analysis and repair strategies were arrived at on the spot, i.e., we had a dead or failed hard disk and needed to restore it as soon as possible. I encourage readers to share their own experiences with disk corruption and file repair. We can all profit from each other's experiences. □

Did you find this article particularly useful?
Circle number 6 on the reader service card.

Figure 7b. Effects of two-bit losses experienced when the sector was written.

The first shift was induced at offset 68 and the second started at offset C0. Note the effect on ASCII data. A space character, hex 20, becomes hex 40 and then a hex 80. The file names are corrupted into graphics characters. The checksum is shifted. This produces an "Error Reading Drive" error. By specifying the Ignore response, you can see the damaged sector.

```
debug
-1100 0 5 1 << first root directory sector - double density format >>
-d100 21f << just look at part of it >>

Offset  Hex  Contents                                     ASCII Contents |Actual
-----
0100  49 42 4D 42 49 4F 20 20-43 4F 4D 27 00 00 00 00  IBMBIO  COM'....|IBMBIO
0110  00 00 00 00 00 00 00 00 60-72 0E 02 00 54 56 00 00  .....r...TV..|
0120  49 42 4D 44 4F 53 20 20-43 4F 4D 27 00 00 00 00  IBMDOS  COM'....|IBMDOS
0130  00 00 00 00 00 00 00 00 60-71 0E 18 00 CF 75 00 00  .....q...Ou..|
0140  43 4F 4D 4D 41 4E 44 20-43 4F 4D 20 00 00 00 00  COMMAND COM....|COMMAND
0150  00 00 00 00 00 00 00 00 60-71 0E 36 00 DB 62 00 00  .....q.6.[b..|
0160  41 4E 53 49 20 20 20 20- ** 1 bit lost **      ANSI      |ANSI

                                A6 B2 A6 40 00 00 00 00      &2&@....|
0170  00 00 00 00 00 00 00 00 C0-E2 1C 9E 01 1C 0C 00 00  .....@b.....|
0180  82 A0 A0 8A 9C 88 40 40-8A B0 8A 40 00 00 00 00  . ...@.0.@....|APPEND
0190  00 00 00 00 00 00 00 00 C0-E2 1C A2 01 82 2C 00 00  .....@b."....|
01A0  82 A8 A8 A4 92 84 40 40-8A B0 8A 40 00 00 00 00  .{$.@.0.@....|ATTRIB
01B0  00 00 00 00 00 00 00 00 C0-E2 1C AE 00 72 4A 00 00  .....@b...rJ..|

                                ** 1 bit lost **
01C0  09 05 0D 2D 55 40 80 81-0D 3D 34 80 00 00 00 00  ...-U@...=4....|BACKUP
01D0  00 00 00 00 00 00 00 01 81-C8 39 84 02 A5 F0 00 01  .....H9...%p..|
01E0  09 05 4D 25 0C 80 80 81-0D 3D 34 80 00 00 00 00  ..M%.....=4....|BASIC
01F0  00 00 00 00 00 00 01 81-C4 3A 04 00 9C 10 00 01  .....D:.....|
0200  09 05 4D 25 0D 04 80 81-0D 3D 34 80 00 00 00 00  ..M%.....=4....|BASICA
0210  00 00 00 00 00 01 81-C4 3A 0C 00 CE 38 00 01  .....D:...N8..|
```


Comparing HardDisk Recovery Software

by Stephen M. Leon

*In the hands of experts, Disk Technician+,
Mace Utilities, Norton Utilities Advanced
Edition, and SpinRite can all facilitate
hard-disk maintenance.*

Asking me to test Norton Utilities Advanced Edition, Disk Technician+ (Version 2.0, Release 4.6), Mace Utilities (Version 4.10), and SpinRite (Version 1.1) at the same time was like giving a child free rein in a candy store. There are so many goodies in these packages that I had a hard time deciding which one to enjoy next.

Although every VAR or systems house should have all four packages available for in-house use, should they also suggest that their clients purchase and use this software? Paraphrasing an old saying in general aviation about gear-up landings: There are those who have already had a hard-disk crash and there are those who will have a hard-disk crash.

Disk drive technology has improved tremendously in recent years. More often than not, what purports to be a crash turns out to be a user doing something very stupid. The same thing appears to be true with the growing number of user claims about virus

infections. However, the issue we have to face is still what we can do to help users protect themselves from data loss.

In testing these four products, it seemed advisable to make life as rough as possible for the hard disk. I have a pair of CMI 6640 30-mega-byte drives that have always been troublesome. They do run reliably on an AT compatible with a Western Digital WD1003-WA2 controller. Naturally, I decided to run these tests on an XT clone using a Western Digital WD10025 WX2 controller.

Each drive had some 20 listed defects on the manufacturer's documentation. Not wanting to make life too easy, I used a low-level format on the first drive but it indicated no errors. I then did a regular system format with DOS 3.3. As a check, I ran Storage Dimension's SpeedStor. It found all but two of the manufacturer's marked errors, and on those two it found errors on an adjacent head.

When a hard disk starts to get a little flaky, the first thing I usually reach for is my copy of the Norton Utilities Disk Test (DT) program. Most of the time it uncovers a sector or two that has suddenly turned bad. DT will mark off the bad sector if you say to do so and if there is no file there. If there is a file, it will tell you

which file so you can take appropriate action before the sector is marked off.

Knowing that I had a disk with some 20 unmarked marginal spots, I proceeded to run DT on it. It gave the disk a clean bill of health. It found nothing wrong! It was time to call in Disk Technician+.

Disk Technician+

Prime Solution's Disk Technician+ is one of those products about which I had read glowing reviews but that I had never used. The blurb on the software package said it all:

"Preventive maintenance software that repairs hard disks by predicting and correcting failures before and after they happen without removing programs and data! . . ."

Prevention takes less than 60 seconds of operator time daily.

It would be unfair to evaluate this fine piece of software on the basis of what some copywriter wrote on the packaging. This is a relatively easy-to-use bit of software that will keep a marginal hard disk going like nothing else on the market. However, before I would suggest that a client buy and use it, I would first ask, in light of the declining cost of reliable hard disks, whether it might not be cheaper to use that marginal disk as a paperweight and buy a new one rather than

Steve Leon is a computer consultant in Cliffside Park, New Jersey. He operates a free-access, three-line Bulletin Board System, at (201) 886-8041, that contains almost 500 MB of public domain software, and he is also a librarian for the PC/Blue public domain software library.

purchase Disk Technician. Sorry, Prime Solutions, but the answer is a resounding yes; it would be less expensive to replace the hard disk.

The 60 seconds of operator time that it takes daily to run Disk Technician is the time it takes to reboot the machine and answer a few questions. Because the software works best after the machine has been running for at least two hours, the manufacturer suggests you run the software at the end of the day. Once you answer the questions, you can then leave the machine on and unattended while it runs its automatic tests—which can take anywhere from 1 minute to 22 hours.

One of the questions Disk Technician asks is: Are you all backed up? And if you do not say that you have backed up, Disk Technician will not run. If you can get your hard-disk users to make a backup at the end of every day, do you want to leave the computer on and unattended every night and weekends while it tests the hard disk?

The first time you run Disk Technician from its copy-protected floppy disk you run the monthly test. Not being a great fan of copy-protected disks, I immediately duplicated the master disk using my Option Board and ran the monthly test off the copy. Disk Technician then checked the disk for 4 hours and 56 minutes. It found 963 errors before it gave me a message that my Disk Technician disk might be damaged. So much for the Option Board copy!

However, with such a high error count, I decided that I would reformat the disk using the Disk Technician's low-level formatting program. Here I learned that the built-in formatting program was hardware-bound. It formatted the 30-MB drive as a 10-MB drive—there being no way to adjust its formatting menu to the specifications of the drive. So I reformatted using DOS, again indicating there were no errors on the disk.

I started up Disk Technician again. It ran for 7 hours and 49 minutes. It found a total of 1,689 errors, repaired 1,449 of them, and told me to get myself a new disk or repair this one. Before I started up, CHKDSK had told me that I had 31,819,776 bytes, 53,248 in three hidden files, 26,624 in one user file, and 31,739,904 available. After 469 minutes, Disk Technician had locked out 188,416 bytes in bad sectors.

Mace Utilities Faces Off Against Disk Technician

What had actually happened was that one of the bad sectors proved to be

a challenge to Disk Technician, so the repair software spent approximately two hours at that sector, building up the error count along the way. To verify this, I reformatted the disk and ran a single pass of Paul Mace's diagnostic utility. The sector that gave Disk Technician so many problems was locked out immediately by Mace. After only a few minutes, Mace gave approximately the same results as Disk Technician.

However, since Disk Technician did not like drive number one, I switched to the other CMI.

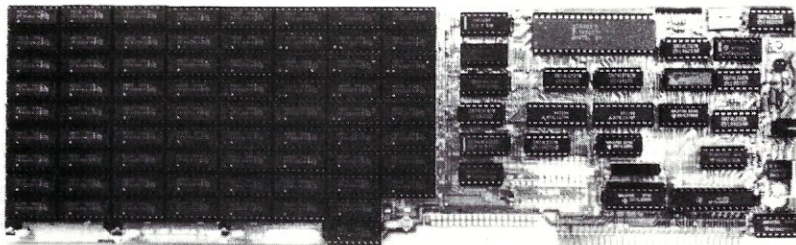
Once again I formatted the disk as an errorless disk, even though the chart on the disk showed 16 errors. I again ran Norton's DT on it, which reported no errors. This time, I had

Mace run a nine-pass diagnostic. It took 1 hour and 49 minutes and reported no errors. I started up Disk Technician again. It ran for 5 hours and 49 minutes, found five errors, and fixed them.

Over the next couple of weeks, this CMI became the most tested and reformatted disk around. I filled the disk with data, selectively deleted files, and defragmented the disk using Mace Utilities. I reformatted the disk and then restored the contents. I ran the daily, weekly, and monthly Disk Technician tests. On several occasions, Disk Technician wound up hanging up on a sector for hours, giving error after error.

A call to Prime Solutions' support line produced the response that I

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should try shifting to an interleaf of 4 (rather than the 3 I had been using). On one of these calls I was told to let it continue, as it would work its way past the sector. On this particular pass, after three plus hours at the same point, I hit control break to allow the program to wind down and stop.

Enter SpinRite

By this time, Steve Gibson's SpinRite had arrived and I added it to the test plan. It made all of the pain and suffering I went through with Disk Technician worthwhile.

SpinRite arrived as Version 1.1, with a note explaining that the soon-to-be released Version 1.2 was essentially identical (except for some minor bug fixes). It describes itself as "a truly new generation of hard-disk utilities," which is a marvel of understatement!

SpinRite is a versatile maintenance package. It allows you to change the interleaf, move data, repair bad sectors, do a low-level format, and realign a disk—all without damaging a bit of data on the disk. And, you don't need to do a backup first. You can stop any time and pick up where you left off later. All of this—and a dandy head parking utility. What more could you ask for?

SpinRite is no speed demon, however. After determining that a 3 interleaf was best for the disk, it took 7 hours and 35 minutes to reformat the disk. In so doing, it found 25 errors on the disk, although Norton's DT could only find five sectors marked as bad with no danger. The Mace Diagnostics had produced the same results as Norton.

By this point I was feeling brave, so I switched back to the first CMI drive. The SpinRite testing of the disk took 8 hours and 45 minutes. It reported seven bad spots, one of which was unrecoverable. My newfound self-confidence got the better of me and I tried Disk Technician again. It again rejected the disk, finding 7,123 errors in 5 hours and 51 minutes. Some 5,000 of these errors came about at one point.

Summing Up

Where does all of this leave us? I think it tells us that there are good and bad points in all of these packages. Even with their shortcomings, they should be available for use when they are needed. I would sum up their strengths and weaknesses as follows.

The Norton Utilities Advanced Edition: Every computer user should have a copy of this available. Everyone accidentally erases a file and Norton's undelete utility pays for itself time

and time again. Norton's Disk Test is useful in determining if a file is sitting on top of a bad sector or in catching a developing bad sector. Many of the other utilities are handy as well. The documentation is good, as is Norton's *Disk Companion* guide to understanding your disks.

Disk Technician: A non-copy-protected version of this software, Disk Technician Advanced, has just been released. It is probably a good idea to have access to a copy—just in case all else fails. Otherwise, it simply does not seem to be worth the time and trouble to use it.

Mace Utilities: Every computer should have access to a copy of Mace, but not every user. Paul Mace's FAT Backup program (RXBAK) belongs in all AUTOEXEC.BAT files. The documentation is confusing to the novice, however. Mace is at its best when it is used by a skilled user after a problem develops. Although the current rage is to run defragmentation programs—and Mace is probably the best of these—the danger of running a defragmentation program is so great that it should not be put into the hands of the novice.

Mace Utilities includes a program to recover damaged or lost dBASE files (dbFIX) and an antivirus pro-

gram (VACCINE). dBASE 3+ files are far more stable than dBASE 2 files, and, again, dbFIX is best when it is kept out of the hands of the novice. (I had VACCINE running for a month, and it warned me every time I did a disk copy and a disk format. However, it was silent when I edited COMMAND.COM.)

SpinRite: SpinRite is another tool that does not belong in the hands of the novice—not because the novice can do damage with it, but rather because it does its job so well that it just is not needed all the time. It is the kind of package that a professional can use to maximize a hard disk and periodically check out disk performance. The documentation is clear and simple, but the program is so simple to operate that the usual practice of *not* reading the documentation is acceptable as well. Systems houses, consultants, corporations, and VARs all should have copies of this fine package.

No matter what kind of disk system you have to maintain, these kinds of hard-disk utilities can be invaluable to restore lost files, isolate potential trouble spots, and generally optimize disk performance. □

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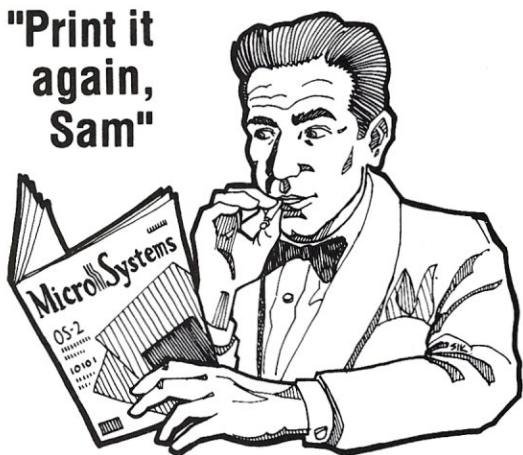
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Hardware Independence for LAN Storage Devices

by Michael Hurwicz

*NetWare's Device
Independent Archive
Server Interface makes it
possible to support a
growing variety of data
storage devices.*

Hardware independence is a strategy that has proven successful for Novell, Inc. It is a strategy that allows Novell to run its NetWare network operating system unmodified on various types of LAN hardware. The key to this ability is the "hardware driver," a small software module with two faces. The face it presents to the LAN hardware is unique to that type of hardware. Such uniqueness is necessary since different kinds of LAN hardware require different inputs to generate the same results, such as sending or receiving a packet. On the other hand, the face that the hardware driver presents to the NetWare operating system does not vary from driver to driver. This, too, is necessary if NetWare is to run in exactly the same way with all drivers.

Michael Hurwicz is a Nashville-based freelance writer who specializes in networking.

There are at least three beneficial results from this approach: First, LAN hardware vendors can support NetWare fairly easily. All they have to do is write a hardware driver, which is not too complicated. Second, end users can change hardware types without having to learn anything new or go through a NetWare upgrade. Finally, Novell can change NetWare without affecting hardware vendors, as long as the interface to the hardware driver stays the same.

Now, Novell is applying this same principle to archival devices, such as tape drives and optical drives. Vendors of such devices can write a driver, a small software module that makes their equipment compatible with the NetWare Archive Server software.

The DIASI Driver

Typically, the driver does not interface directly with the storage device, but rather with other software that the vendor already has for controlling the device. Thus, starting from the bottom, the four layers of the cake are: the hardware, the vendor-specific software, the driver, and the Archive Server software. The driver is written according to the specifications contained in the Device Independent Archive Server Interface (DIASI, pronounced "Daisy") definition. Thus, it may be referred to as the "DIASI driver."

The Archive Server, which works only with NetWare Version 2.1 and above, is a dedicated microcomputer that allows authorized users to archive files from NetWare servers to block-addressable storage devices. An authorized user at any workstation on the LAN can submit "scripts" to the Archive Server, requesting immediate, delayed, or repetitive backups of selected files. Typically, users employ a menu-driven utility that simplifies script creation and submission. The Archive Server fulfills the requests, producing an audit trail as it does so.

Because of the Archive Server's device independence, the same scripts will work with any compatible device,

whether it is a 60-megabyte tape drive or a multi-gigabyte optical "jukebox." Such device independence brings the same benefits that hardware independence does for LAN hardware: consistency for users, easy entry for vendors, and freedom for Novell to enhance the Archive Server software without danger of creating incompatibilities for hardware devices.

Novell provides C source code to developers that implements part of the DIASI driver. Developers add the required functions to this code, and compile and link to form a .COM file. When executed, the .COM file terminates and stays resident in the random-access memory of the Archive Server machine.

(By the way, this method of working with developers to create DIASI drivers could change, as could the specifications for the DIASI interface itself. Check with Novell for any changes that may have occurred since this article went to press.)

The functions provided by the developer are called by the Novell software. These functions comprise the DIASI interface. They fall into three classes: error reporting, initialization and reset, and archiving and restoring.

Error Reporting

All of the functions provided by the developer can return error information by setting a global variable. The DIASI interface supports 15 error codes, such as "device is write protected," "end of media," and "no cartridge." The C declaration for the "device status code" variable, and the 15 possible error conditions would be:

```
int deviceStatusCode;

/* Possible error conditions:

write protected
cartridge needs certification
cartridge changed
end of media
no cartridge
data error
cartridge failure
blank sector read
device not ready
device timeout
device failure
host adapter failure
hardware failure
invalid parameter */
```

A sixteenth code —namely, 0 —indicates no error.

The structure in which additional data can be returned to the Archive Server, when this is necessary, would be:

```
struct {
int size;
char *data;
} DeviceSense;
```

The data returned in this structure is handed up to the Archive Server, which displays it on the screen with the error report. It is typically used for providing more detailed or precise error information. For example, a manufacturer might want to advise the user to check whether the tape unit is plugged in, rather than rely on a more general error message such as "device timeout" or "device not ready."

The "size" variable gives the length of the data in bytes. If the "size" variable is equal to negative one, the data is a null-terminated character string. This is the usual case,

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by Thom Hogan

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since the data is to be displayed on the screen. "Data" points to the string.

Initialization and Reset Functions

The initialization function (*InitializeDIASI*) allows the Archive Server software to determine the type of media, the size of blocks to be transferred, and several other pieces of information that it requires in order to start communicating with the storage device. The initialization function sets seven global variables. As they appear in C, they would be:

```
int archiveDeviceMediaType;
int bytesPerLogicBlock;
```

```
int mediaIsReusable;
int mediaNeedsCertification;
int optimalBufferSize;
int cartridgeChangerSize;
long totalLogicalBlock;
```

The "archive device media type" identifies specific backup devices, typically one for each different model. These numbers are assigned by Novell, to ensure that they are unique.

The "bytes per logical block" variable gives the number of bytes in each block of information that is read from or stored to the device.

The "media is reusable" variable indicates whether the

Figure 1. The seven basic DIASI routines.

```
/* Functions provided by the developer for the DIASI driver. In each case, "device" indicates which
device, since a single Archive Server may in theory support many. However, currently this will always
be 0, since the current Archive Server supports just one device per server. */

/* 1. MOUNT CARTRIDGE */

MountCartridge(device, autoSearch)
int device;
int autoSearch;

/* A TRUE (or 1) for the "AutoSearch" parameter requests the device to search for the first available
block. WORM devices can typically do this, while tape drives cannot. Tape drives return FFFFFFFE to
indicate this inability. The Archive Server will then look at a "trailer" record to determine the
first available block.

2. DISMOUNT CARTRIDGE */

DismountCartridge(device)
int device;

/* 3. WRITE SYSTEM BLOCK */

WriteSystemBlock(device, buffer, blockID, buffersize)
int device;
char *buffer;
int blockID;
int buffersize;

/* The cartridge (or other storage media) is divided into the "user" area and the "system" area. The
system area contains the header and trailer for the cartridge and an index to the databases contained
on the cartridge. The databases contain records of archiving operations. Databases are stored on
the file server and are normally consulted there. However, databases can be restored from the backup
media, just as archived files can.

The BlockID parameter indicates whether a header (BlockID equals 0), trailer (BlockID equals 1) or
database index (BlockID 6 to 255) is to be written.

4. READ SYSTEM BLOCK */

ReadSystemBlock(device, buffer, blockID, blocksToRead)
int device;
char *buffer;
int blockID;
int blocksToRead;

/* 5. WRITE BLOCK */

(device, buffer, StartBlock, BlocksToWrite, EndOfRecord)
int device;
char *buffer;
unsigned long StartBlock;
int BlocksToWrite;
int EndOfRecord;

/* On the last write for a particular file or record, the calling program will make EndOfRecord TRUE.
This tells devices that perform file-oriented storage and retrieval where the file or record ends.

6. READ BLOCK */

ReadBlock(device, buffer, StartBlock, BlocksToRead, StartRecord)
int device;
char *buffer;
unsigned long StartBlock;
int BlocksToWrite;
int StartRecord;

/* StartRecord tells the device where the record or file starts. Again, this is for devices that
perform file-oriented storage and retrieval.

7. GET DEVICE STATUS */

GetDeviceStatus(device)
int device;

/* This function updates the global error code variable discussed above under "Error reporting." */
```


media can be erased and overwritten, or if it is a "write once, read many times" (WORM) type of device.

The "media needs certification" variable tells the Archive Server software whether it needs to test the media to make sure it is working correctly, or if the media does not require testing. Magnetic tapes must usually be certified before they can be used.

The "optimal buffer size" variable specifies the best buffer size for reads and writes. The Archive Server will try to set aside a buffer of that size.

The "cartridge changer size" indicates how many cartridges the cartridge changer can hold. Currently, this should be hard-coded to 1.

The "total logical block" variable gives the remaining capacity of the storage device in logical blocks.

At the same time, the initialization function performs whatever routines are necessary to get the device ready for use. The reset function (*ResetDIASI*) does not accept any data from or return anything to the calling program. It can be a "no op" that simply returns to the calling

*Because of the
Archive Server's device
independence, the same
scripts will work with any
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whether it is a 60-megabyte
tape drive or a multi-
gigabyte optical "jukebox."*

program without doing anything. This function allows the developer to perform any actions appropriate to shutting down the device.

Archive and Restore Functions

In order to be universally applicable, a device-independent interface has to be relatively simple. Accordingly, DIASI requires just seven basic routines for mounting and dismounting cartridges, reading and writing blocks of information, and obtaining the status of the storage device. Figure 1 shows function definitions in C for each routine.

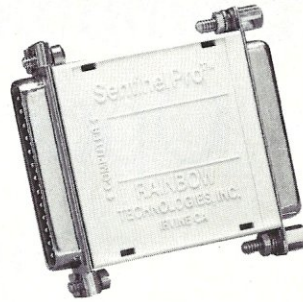
Hardware independence has proven successful for LAN hardware. The DIASI interface now brings the advantages of hardware independence to archival storage devices. □

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Communication Techniques for Optical Disc Storage for Networks

by William E. Maness

Getting optical storage devices to communicate with a LAN can be complicated, but the rewards are worth it.

WORM (write once, read mostly) optical discs are fast becoming the option of choice to store large volumes of non-volatile information. At the same time, local area networking technology has always been an attractive way to transmit information and share resources. Therefore, LANs and WORM discs seem a perfect match to make large amounts of information available to a large number of users. Unfortunately, the reality of setting up a LAN with WORM disc information support can be a complex problem.

This case study centers around the Photo Access Security System, an integrated photo ID production and access control system developed by US Imaging & Security, Inc. The system discussed here was installed in a nuclear

facility to produce photo ID's, retain the images on optical discs, and transmit specific images to various stations around the facility. Since the subject of this case study is a nuclear facility, they are reluctant to discuss their security system in print, so, for purposes of this discussion, we'll call them Continental Nuclear.

The Application: Image Verification

Photo Access's objective is conceptually simple: to digitize and store an employee's photograph from a video camera; make an ID badge from that photo, including a magnetic stripe or bar code; re-display the photo image whenever requested, either by manually inputting a request on a keyboard or by using the magnetic stripe or bar code. However, Continental Nuclear employs more than 14,000 people. To provide this kind of data access in a network environment obviously required some sort of very high capacity storage.

Continental Nuclear has a central badging station, two file servers handling mirrored data, an opti-server, three optical disc drives, and seven verification stations distributed around the plant. US Imaging & Security chose Standard Microsystems' ARCNET as the communications medium and Banyan VINES 286 software as the core of the networking system. A network diagram is provided in Figure 1.

Since employee photographs would not need to be changed often, WORM technology seemed perfect for this application. We were looking for the utmost in optical disc technology when we began the project. We tried an optical product from one vendor but quickly determined that it was subject to failure in the field. Therefore, we decided that the PC-800E optical disc drives from Storage Dimensions was the appropriate technological choice.

The Technology: A High-Capacity Storage Device

The PC-800E uses a disc drive produced by Maxtor, Inc. This drive, the RXT-800S, accepts a pre-formatted, 5 1/4-inch optical platter that is enclosed in a protective cartridge, model number OC-800. The OC-800 cartridge is a

William E. Maness is President of US Imaging & Security, Inc. in Seattle, Washington, and co-designer of the Photo Access Security System.

plastic sandwich disc that uses a PMMA (Poly-methacrylate) substrate with a Methine dye coating. Data is recorded on the platter by thermally altering the Methine dye using a low power laser diode. This diode laser emits coherent infrared light at a frequency of 780 nanometers at a maximum output of 4.4 milliwatts. The RXT-800S reads and writes on the OC-800 cartridge within preformatted sectors that are 2048 bytes long. The RXT-800S also includes an embedded small computer systems interface (SCSI) and can support 400 MB per cartridge side of usable storage. However, only one side can be used at a time. An electrical block diagram of the drive configuration is provided in Figure 2.

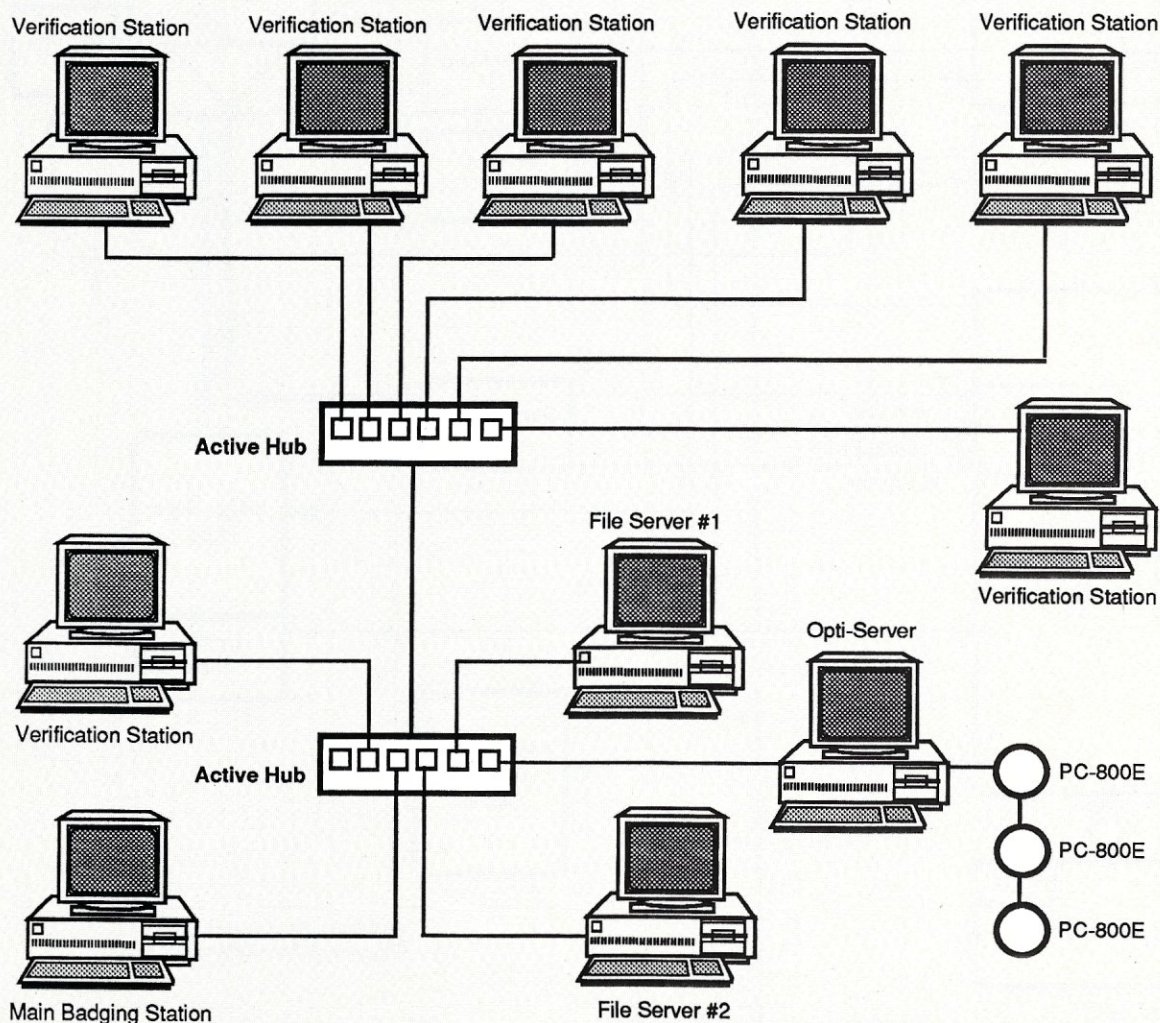
The Storage Dimensions system places the disc drive unit in an external enclosure along with a power supply and a cooling fan, making it into an excellent stand-alone storage subsystem that does not draw on our already heavily loaded computer. This setup also allows up to seven PC-800Es to be daisy-chained on the SCSI bus, providing a maximum of 2.8 gigabytes of online data storage to an AT class machine. And since a WORM disc

can never be overwritten, it is possible to "step back in time" and examine the state of the disc at any time in the past. Storage Dimensions provides utilities to do that.

Storage Dimensions provides an easily installed device driver that delivers full DOS access to the drive, making a WORM device perform as if it were a normal read/write magnetic drive. So the entire 400 megabytes that are available can be accessed as a single DOS drive. There are some penalties for this transparency, however. A program must be run that patches COMMAND.COM to increase the buffer size from 512 bytes to 6144 bytes. This slows down normal magnetic device access to some extent.

The device driver also supports a direct access OEM mode. It is this mode that US Imaging & Security chose to work within, since we had complete control over program requests to the drive. This was done in part because we needed the ability to use program-specific platter formats for security reasons. Also, since we didn't need the transparent DOS-type access anyway, we decided to dispense with the associated memory and processing overhead.

Figure 1. The ARCNET network at Continental Nuclear, which includes a central badging station, two file servers handling, an opti-server, three optical disc drives, and seven verification stations.



The Network Link: Information Retrieval

Now came the hard part, getting the data stored on the PC-800Es to the workstation at the other end of the coax.

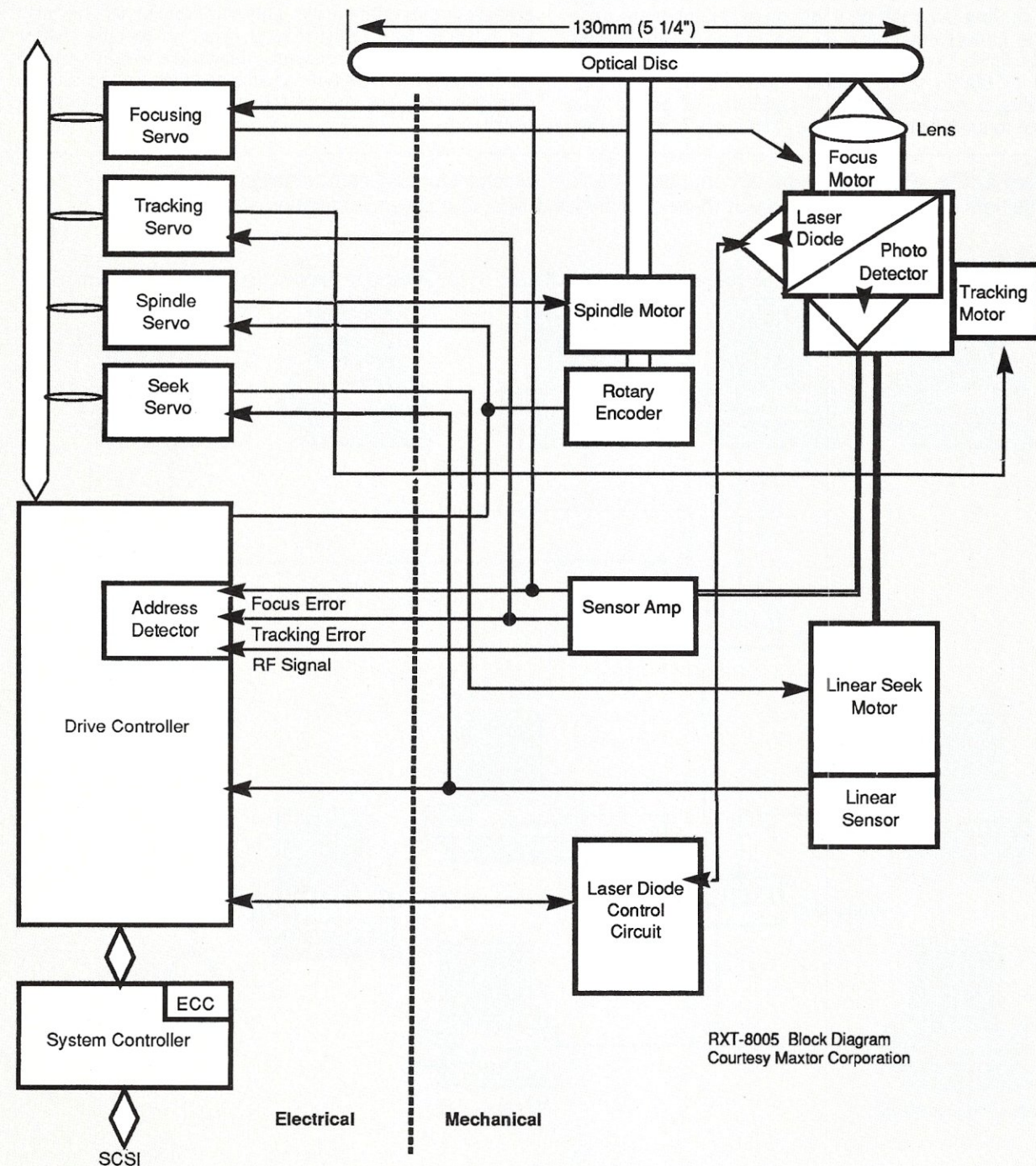
The solution we implemented was to install a dedicated Compaq 286 to control the PC-800Es. We call this unit an opti-server. Creating this opti-server involved writing software that would look at the network disc for a flag that would be set in a semaphore file. When the software sees this semaphore, it copies the appropriate file from the optical disc to the magnetic LAN disk, sets an answering semaphore, and waits for the next request. During

this time, the requesting station watches the semaphore file for an answering semaphore, and when it receives an answer, it reads the photo file on the LAN as a normal DOS disk. Therefore, this approach requires a dedicated computer to handle the optical discs and cooperative software in both the requesting station and the opti-server.

This is the basic process flow:

- Verification Station (VS) software receives a request

Figure 2. A block diagram of the RXT-800S, which accepts pre-formatted optical platters. The diagram is courtesy of Maxtor Corporation.

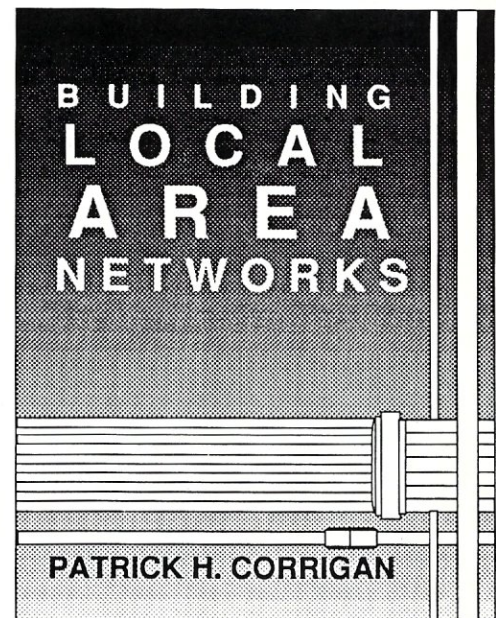


BUILDING LOCAL AREA NETWORKS

by Patrick H. Corrigan

Learn about Local Area Networks. From the basic components to complete network installation, here is a practical guide that PC systems integrators can use to build and implement PC LANs. **Building Local Area Networks** provides the specifics of building and maintaining PC LANs, hardware configurations, software development, cabling, selection criteria, installation, and on-going management — all of which are described in a detailed, "how-to" manner with numerous illustrations and sample LAN management forms.

If you want to find out what LAN is and how it works, **Building Local Area Networks** is the ideal book for you. A complete overview of the LAN operating system is provided. Author **Patrick H. Corrigan**, a seasoned networking professional, gives particular emphasis to Novell's Netware, Version 2.1. Additional topics covered include the OS/2 LAN Manager, Tops, Banyan, VINES, internetworking, host computer gateways, and multisystem networks that link PC's Apples and mainframes.



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for a specific employee photo image.

- VS software looks at the common database located on the VINES 286 server for textual information.
- VS software writes a semaphore and an employee number in the PASS.SEM file on the VINES 286 server.
- Opti-server software reads the PASS.SEM file.
- Opti-server software checks the mounted platters and, if possible, copies the appropriate image file to the network magnetic disk.
- Opti-server software writes a semaphore, indicating either that a file is currently available or that the file could not be found.
- While waiting for the above semaphore, VS software reads PASS.SEM and loads the photograph to the screen or displays an error message, if necessary.
- As soon as the photo is no longer needed, VS software deletes the file from the magnetic disk.

Data communications from the PC-800Es depend on the PASS.SEM file. The format we used for this file is shown in Listing 1. Listing 2 displays code that instructs the workstation to "watch" the PASS.SEM file for a semaphore addressed to this station. Listing 3 displays the code fragment that sets a semaphore in the PASS.SEM file for servicing.

An Alternate Optical Approach

Another approach was tried as well, to combine the function of the optical server described above and the main badging station.

The PC-800Es were tied to the main badging station in the same way they are in a non-networked configuration. The badging software then checked the semaphore file once per second for a request. When a request was received, the badging software suspended its operations, serviced the request like the dedicated opti-server, and then resumed operations. While this approach worked, it did mean a brief interruption of work occurring at the badging station. We deemed this unacceptable, especially when multiple requests were coming in during busy periods such as during a shift change.

When we needed to run generic DOS programs across a LAN to the PC-800Es, we found another technique must be used. A more general approach, applicable to diverse applications, is currently being tested. The use of Banyan's "PC-based service" eliminates the magnetic disk drive copying scheme and its associated overhead. With this technique, each opti-drive is assigned a DOS drive name and the opti-drive server becomes another Banyan recognized server on the network.

WORM/LAN communications technology is in its infancy. These techniques are quite straightforward, but,

when developing WORM/LAN applications, be aware that you are on the leading edge of the technology with all that it implies. □

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Product Information

The PCE800E is available for a retail price of \$4,495.

Storage Dimensions also has introduced an improved version of its drive, the LaserStor, which uses a conventional DOS Winchester drive to cache data to and from the optical disc to improve throughput performance. The LaserStor also sells for \$4,495.

Storage Dimensions
2145 Hamilton Avenue
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Listing 1. The PASS.SEM file, which handles data communications from the PC-800S

```
struct net_req {
    short type;          /* type of network request */
    char fn[64];         /* filename of file to move */
    long time_stamp;     /* time of request */
    long platter;        /* platter number of target */
    long sector;         /* sector number on platter */
};
```

Listing 2. The program that instructs the workstation to monitor PASS.SEM.

```
lseek(sem_handle, (long)0, SEEK_SET);
/* check for locking */
if (!locking(sem_handle, LK_NBLCK, (long)sizeof(network_request)))
{
    /* if not, read req */
    read(sem_handle, (char *)&network_request,
        sizeof(network_request));
    /* check time stamp */
    if (network_request.time_stamp != last_time_stamp)
    {
        /* code to handle semaphore */
    }
    unlock_semaphore_file(); /* reset file for other use */
}
```

Listing 3. This program sets a semaphore in PASS.SEM for servicing.

```
tpn = time(NULL); /* get time of write */
network_request.time_stamp = tpn; /* set time in structure */
network_request.platter = platter_number; /* set platter number for operation */
network_request.sector = sector; /* set sector number for operation */
strcpy(network_request.fn, ofn); /* set filename for operation */
lseek(sem_handle, (long)0, SEEK_SET); /* rewind file */
/* wait for file to be clear */
while (locking(sem_handle, LK_NBLCK, (long)sizeof(network_request)) && filelength(sem_handle));
/* write semaphore */
write(sem_handle, (char *)&network_request, sizeof(network_request));
lseek(sem_handle, (long)0, SEEK_SET); /* rewind file */
/* unlock file */
locking(sem_handle, LK_UNLCK, (long)sizeof(network_request));
```


Rewritable Optical Disc: A New Data Storage Medium

by Ed Dowgiallo

Although slower than magnetic media, rewritable optical discs may offer a new approach to high-capacity network data storage.

Could you use a 326-megabyte Bernoulli cartridge that was warranted by the manufacturer for 10 years? If your response is, "Where do I send the purchase order?" then you're probably ready to take a look at erasable optical storage, the latest innovation in removable mass storage.

Removable mass storage for microcomputers has come a long way since the 14-inch disk platters of the early S-100 days. Those early 14-inch platters gave way to 8-inch floppy diskettes, and later to the even smaller media forms we use today. The 3¹/₂-inch, high-density floppy with 1.44

Ed Dowgiallo is an independent computer consultant based in Delran, New Jersey. In addition to writing for computer magazines, he does custom design and programming in the area of databases, data communications, and operating system extensions.

megabytes (MB) of formatted storage offers greater storage capacity than the DSDD, 1.2-MB, 8-inch floppies that were once the Cadillac of microcomputer storage. In recent years, we have seen the advent of the Bernoulli removable disk, and most recently the Tandon Ad-Pac, which is in essence a removable hard drive. Even as Tandon receives FCC approval for its 30-MB Ad-Pac, new devices based on optical media are arriving on the scene.

Initially, erasable optical devices will be slow—120 milliseconds (ms) average access time—but they will be harder than magnetic devices (airport x-rays are no problem, for example) and have at least as much capacity as the larger, fixed, magnetic drives. Did I forget to mention that those 326 MB represent storage capacity per side?

Unless there is a silent surprise waiting in the wings, Advanced Graphic Applications, Inc. (AGA) is the first company to deliver a "plug-and-play" optical data storage device. Its DISCUS Rewritable optical disc system is packaged as system software and a controller card from AGA with a drive made by Olympus Corporation and disks produced by 3M, Inc. At the time of this writing, the first units were scheduled to ship in November. AGA indicates that the complete system will be initially priced at \$4,995 per system. The 326-MB 3M disks will cost about \$250 each.

How Good Is It?

Sources at AGA indicate that the first production unit has an 88-ms average seek time. This compares with magnetic hard-disk speeds of 28 ms to 60 ms, depending on the source and brand of your hard disk. IBM has tended to ship slower hard-disk drives with its lower priced models, as have several IBM clone manufacturers. One manufacturer reports that its competing 115-MB optical disc drive has a seek time of 135 ms, while its 130-MB Winchester drive has an average seek time of 13 ms (20 ms for the disk drive seek).

If what you're looking for is speed, as would be the case with a database server, AGA's product is not yet for you. If you're looking for capacity and speed is a secondary issue, as would be the case with a network file server for a departmental word processing system or imaging system, the DISCUS Rewritable is something you might look at now.

The capacity of the new AGA drive is 326 MB per side using 1024-byte sectors, or 297 MB per side at 512 bytes per sector. The error rate for the drive is about one in a trillion, which means you should double check every 128,000 MB or every million megabits or so. Using AGA's combination of hardware and software, the DISCUS Rewritable appears to your computer to be just another very large hard disk drive. In fact, you can use it in place of a hard disk, as has been amply demonstrated by AGA's prototype units. It doesn't take a great deal of imagination to realize that, barring the slower speed (which will improve), optical drives like AGA's can eliminate the storage problems of the average stand-alone PC user for years to come. Although some network applications may tend to require faster storage, even here the unit has its place as a reliable mass storage device.

How Does It Work?

The mechanisms lying at the core of this new technology are a very clever combination of magnetic and optical storage methods. Where WORM (Write Once, Read Many times) optical systems provide a permanent data record because information is actually etched into the platter's surface, AGA's magneto-optical approach couples magnetic media with optical technology to provide rewritability.

The central principle upon which the device is built is that there are materials with magnetic properties that can only be changed when the material is hot. These materials will still hold the magnetic field when they are cool, but the orientation of that field can only be changed when the material is heated. Thus, to record information, you heat the material, apply a magnetic field that changes the direction of the substrate to represent either a one or a zero, and let the material cool again. Are these materials completely immune to magnetic realignment when they're not hot? No, but the intensity of the magnetic field required to induce such a change on the cool material is very high.

The substrate material in the optical disk is a polycarbonate. As you might expect this early in the game, the exact type of material used is a trade secret. By the way, manufacturers are calling these items discs instead of diskettes because they are rigid and have many times the capacity of the ubiquitous floppy diskette. At any rate, the substrate material is the active component of the disc, holding the magnetic field and only permitting it to be changed when it is hot (see Figure 1).

The substrate is further coated with glass to protect it. As with compact discs, there is no more worrying about spilling coffee or getting finger prints on the surface of the disk. If the disc gets dirty, you can just clean it off and no great harm is done.

In order to make these discs double sided, a two-sided mirror is embedded between two layers of substrate material. The laser light used for reading and writing to these discs is then reflected before it reaches the second substrate layer. When you fill up the 326 MB on one side, you can just flip the disc over and you have another 326 MB ready to go! Users of the early single-sided floppy disk drives will remember doing this kind of thing with double-sided floppy disks.

The write head in these units consists of a laser and a

The DISCUS "plug-and-play" rewritable optical disc system.

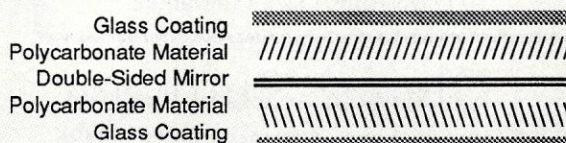


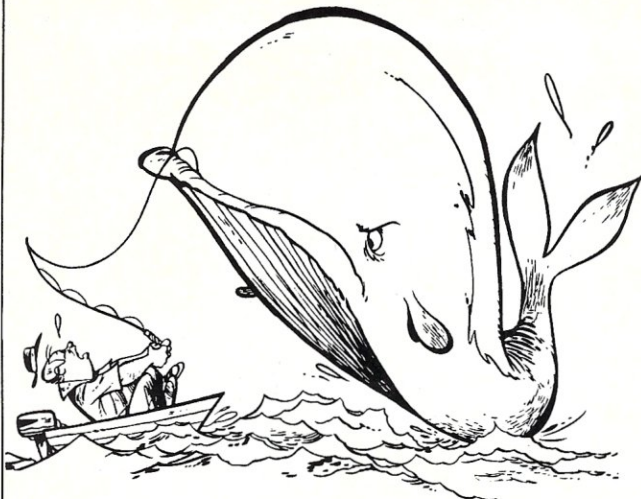
magnetic coil. The laser is used to heat the material at the same time that the magnetic field is applied to the same area to change the direction of magnetization in the material. Since the magnet has no effect on cool material, the density with which bits can be written is entirely dependent on how accurately the laser can be focused and aimed. As media densities continue to increase, this technology will have an advantage over pure magnetic strategies because the limitation here is optical rather than magnetic; it is much more difficult to focus a magnetic field than a laser beam.

We have discussed at some length the fact that the substrate material is only magnetizable when heated, but you may be wondering how the optics are involved in this whole process. Magnetic fields polarize light. Light consists of planar electromagnetic waves, similar to the waves you see when you throw a rock into a pond. When these waves pass through a magnetic field of sufficient intensity, "vibrations" are caused in the waves, just as when the waves in the pond pass through a small rock breaking the surface of the pond. When a light wave has such a vibration within it, it is said to be polarized.

One of the physical limits on the recording density of magnetic media is the fact that it is harder to detect and read the variations in the magnetic fields than it is to change them in order to write in the first place. This is because, on normal magnetic media, reads are done by attempting to directly detect the magnetic fields that were written. With the new magneto-optical technology, the read head takes advantage of the fact that magnetic fields

Figure 1. 3M's erasable discs are made of a special polycarbonate material that is magnetizable only when hot. The double-sided mirror permits two-sided discs to be made.





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polarize light to detect the magnetic field indirectly.

The read head in these devices consists of a laser and a polarization filter. The laser light is reflected through the substrate and off the mirror that is sandwiched between the two substrate layers (Figure 2). On returning, the laser light is passed through a polarization filter to a special diode that is used to detect the returning light. The polarization filter will only allow light that is polarized in a particular way to pass through. If light reaches the diode, the position contained a one. If no light reaches the diode, the position contained a zero (see Figure 2). What could be simpler?

One of the great advantages of this technology is that the recording density is limited by the precision with which the laser can be controlled, and not by the ability to distinguish and directly detect magnetic fields. Even while the International Standards Organization (ISO) considers the adoption of the 650-MB format as a standard for 5¹/₄-inch optical discs, proposals are being put forth for a 2-gigabyte (that's 2 billion bytes) 5¹/₄-inch disk

*... the recording density
is limited by the
precision with which
the laser can
be controlled, not by
the ability to distinguish
and directly detect
magnetic fields.*

format, as well as formats for 3¹/₂-inch optical discs. The other really great advantage is there is no possibility of a head crash since the read/write head does not have to touch the spinning media.

How Does It Connect?

As currently configured by AGA, the DISCUS Rewritable uses a Small Computer System Interface (SCSI). The drive itself fits in a bay for a full-height disk drive, and the controller board is available for either an 8- or 16-bit expansion slot. Installation is no harder (or easier for that matter) than installing a normal full-height magnetic hard disk.

Does It Require Special Software?

In order to use DISCUS Rewritable in your computer, you will need MS-DOS 3.0 or higher. AGA supplies several special software components with the unit:

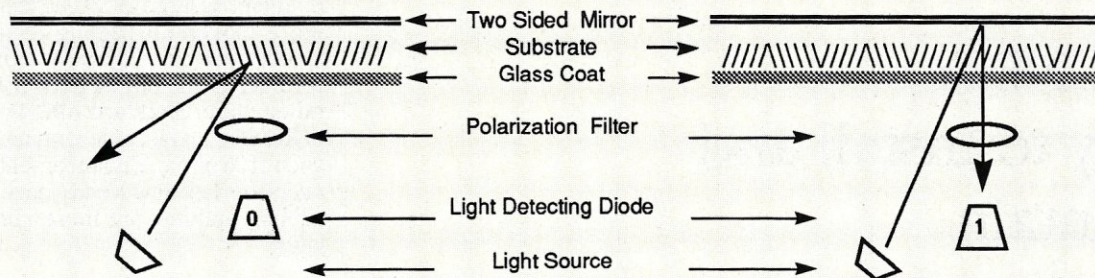
AGADRV.SYS is a special device driver that will make the DISCUS Rewritable look like a normal hard drive to your operating system.

AGAPART.EXE is used to partition the DISCUS Rewritable into multiple logical drives if you prefer to use it that way. RFORMAT.EXE formats the DISCUS Rewritable.

DOSPATCH.EXE can be used to patch DOS to support partitions in excess of 32 MB, obviating the need to create partitions with AGAPART.EXE.

With the aid of AGADRV.SYS, you will be able to run

Figure 2. Reading consists of reflecting light off the magnetized substrate and passing it through a polarization filter to a diode. Only light polarized a particular way will reach the light-detecting diode.



all the software you normally use with your hard drive. During the prototype demonstration at the New York PC-Expo last June, WordPerfect and Microsoft Windows were run directly off the DISCUS Rewritable. The only possibility for incompatibility in application software would be applications or utilities that bypass the hard disk device driver and implement their own low-level disk I/O. It seems unlikely that there is a great deal of software that would fall into that category. Most of the software that is likely to have this kind of problem will be in the area of specialized disk utilities (i.e. disk optimizers, disk patch utilities, and erased file recovery programs).

What Can You Do with It?

As these units enter mass production, a number of new applications will become available that take advantage of this new technology. These applications will be based on combinations of text, images, and voice data. The applications will span the office environment in the form of highly sophisticated voice mail and imaging systems, and will enter the consumer market as well to support such things as digital video and computer animation.

The electronic technology required for home computer processing of broadcast signals is already available! CableSoft, a company in Iowa, is manufacturing a board that will make your PC compatible with subcarriers on 150 cable TV channels. At present, that board is currently part of a product that monitors stock quotes on subcarriers on the financial news channel.

In addition to these new applications, consider the improvements to things you do now. The new erasable laser discs are lighter, are less susceptible to damage, and are more immune to x-rays and magnetic fields than products such as Tandon's new Ad-Pac removable hard drives, or any other form of purely magnetic mass storage. You can thus feel about as safe mailing them as you could with most other relatively fragile things (photographs come to mind), assuming that you provide a reasonably stiff mailing container.

If you are a developer, you can maintain complete, bootable, and fully customized environments on different laser discs and switch environments as easily as switching disks. You no longer have to fool with multiple partitions for MS-DOS, OS/2, Xenix, etc. (Nor do you have to contend with Murphy's Law: "The partition you are currently working in is the one with the least amount of storage.") These laser discs will have plenty of storage, and it will be cheap enough to use to segregate the programming environments in which you work. What you used to

separate by partitions on a large disk drive you can now separate by using multiple discs.

What Are the Risks?

There are risks that you will expose yourself to by jumping onto a new technology early. Erasable optical disks are no exception to this rule. The biggest risk in immediately purchasing these devices is that the standards issue has not yet had time to resolve itself. Also consider the fact that the earliest devices will also be the slowest devices.

AGA has been a major player in attempting to get standards adopted early for these units, and thus avoid the standards wars that seem to accompany the introduction of any new technology. To a large extent, they seem to have gotten most of the contributors to agree, although some manufacturers are planning to produce units that follow both the proposed standard and their own proprietary formats. Be sure to investigate the standards issue when considering the different brands that should be available early in 1989.

With regard to speed, it is highly likely that, within a year, these devices will provide access times under 40 ms. That is to say, they will have reached the speed of the average hard disk available today. Manufacturers are a little hesitant to commit themselves to specific predictions, but this is not surprising for a brand new technology since there is no historical pattern on which to base forecasts. For network managers contemplating a \$4,000 to \$5,000 purchase, it might be just as well to wait. Manufacturers are also predicting that the cost of the system will be cut by 50 percent to 75 percent once it is in mass production. Of course, if everyone waits for that to happen, it will never be in mass production. Never fear, though, corporate sales alone should be enough to cause prices to drop. □

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Circle #264 for more information

by Patrick H. Corrigan

ARCNET: Easy to Install and Maintain

ARCNET, originally developed in 1977 by Datapoint, is one of the oldest existing LAN systems. The primary architect of ARCNET was John Murphy, who is now head of development Performance Technology, a developer of LAN operating software. Standard Microsystems Corporation (SMC) developed the first ARCNET controller chip in 1981, and the first ARCNET controller board for IBM-type PCs in 1983. Today, ARCNET is one of the most popular LAN hardware systems in the world and comprises an estimated 25 percent of all new LAN installations. This figure includes all LAN types; the estimate for PC LANs is much higher. For example, it is estimated that more than half the installations of Novell's popular NetWare operating software use ARCNET hardware.

According to Ben Wolfe, chairman of the ARCNET Trade Association, there are approximately 135 manufacturers of ARCNET products. ARCNET is supported by many LAN operating systems, including Novell NetWare, Banyan VINES, Western Digital Vianet, CBIS Network OS, Performance Technologies POWERLAN, Univision LifeNET, and many others. ARCNET is also widely used in industrial and manufacturing control systems. ARCNET interfaces are available for various expansion buses, including IBM PC, PC AT, PS/2, S-100, Multibus, VME bus, Qbus, STD bus, STE bus, and Nubus (used by the

Apple Macintosh). Wolfe states that more than 1.3 million ARCNET nodes will be installed by the end of 1988. The major manufacturers of ARCNET currently include SMC, Pure Data Corporation, Thomas Conrad Corporation, and Tiara Computer Systems. (A comparative review of ARCNET products, "Comparing ARCNET Cards," was published in *Micro/Systems*, October 1988.)

Why is a LAN system that does not bear an IEEE stamp of approval so popular? There are several important reasons: reliability, flexibility, performance, ease of installation, and ease of fault diagnosis are among them. The consensus among LAN resellers and installers is that ARCNET is the easiest LAN to install and troubleshoot. Once installed, ARCNET controllers rarely cause trouble, and, due to the "star cluster" topology of ARCNET, isolating sections of the network for diagnosis is quite easy.

While ARCNET is not the fastest LAN around at 2.5 megabits per second (mbps), its token-passing protocol provides performance that will not degrade quickly under load. ARCNET also provides a great deal of cabling flexibility. Additionally, virtually any manufacturer's ARCNET controller will function properly in the same network with any other manufacturer's controller. ARCNET seems to have achieved a degree of standardization not always available in the 802.3 Ethernet and StarLAN world.

Topology and Cabling

The standard topology for ARCNET is a star-cluster scheme, with ARCNET nodes (or stations) attached to distribution devices called hubs. There are two types of ARCNET hubs: active and passive. An active hub is a powered unit that serves as a distribution de-

vice and signal amplifier, while a passive hub only distributes signals over short distances. Active hubs may have between 4 and 64 ports, while passive hubs have 4 ports. By using multiple hubs, an ARCNET LAN can have a diameter as large as 20,000 feet, meaning a maximum cabling distance of 20,000 feet or effectively four miles from any node on the network to any other node. Standard ARCNET cable is RG-62 coaxial cable with an impedance of 93 ohms. Enhancements made over the last few years have added cabling options, but more about this later.

The ARCNET Cable Access Scheme

ARCNET is a token bus network. A "bus" network has a common cable set, and all signals are broadcast across the entire network simultaneously. The signals are only received and acknowledged by the stations to which they are addressed. ARCNET uses a Logical Token Passing scheme to control cable access. In token passing systems, there is an electronic signal, a "token," that is passed from station to station in a predetermined order.

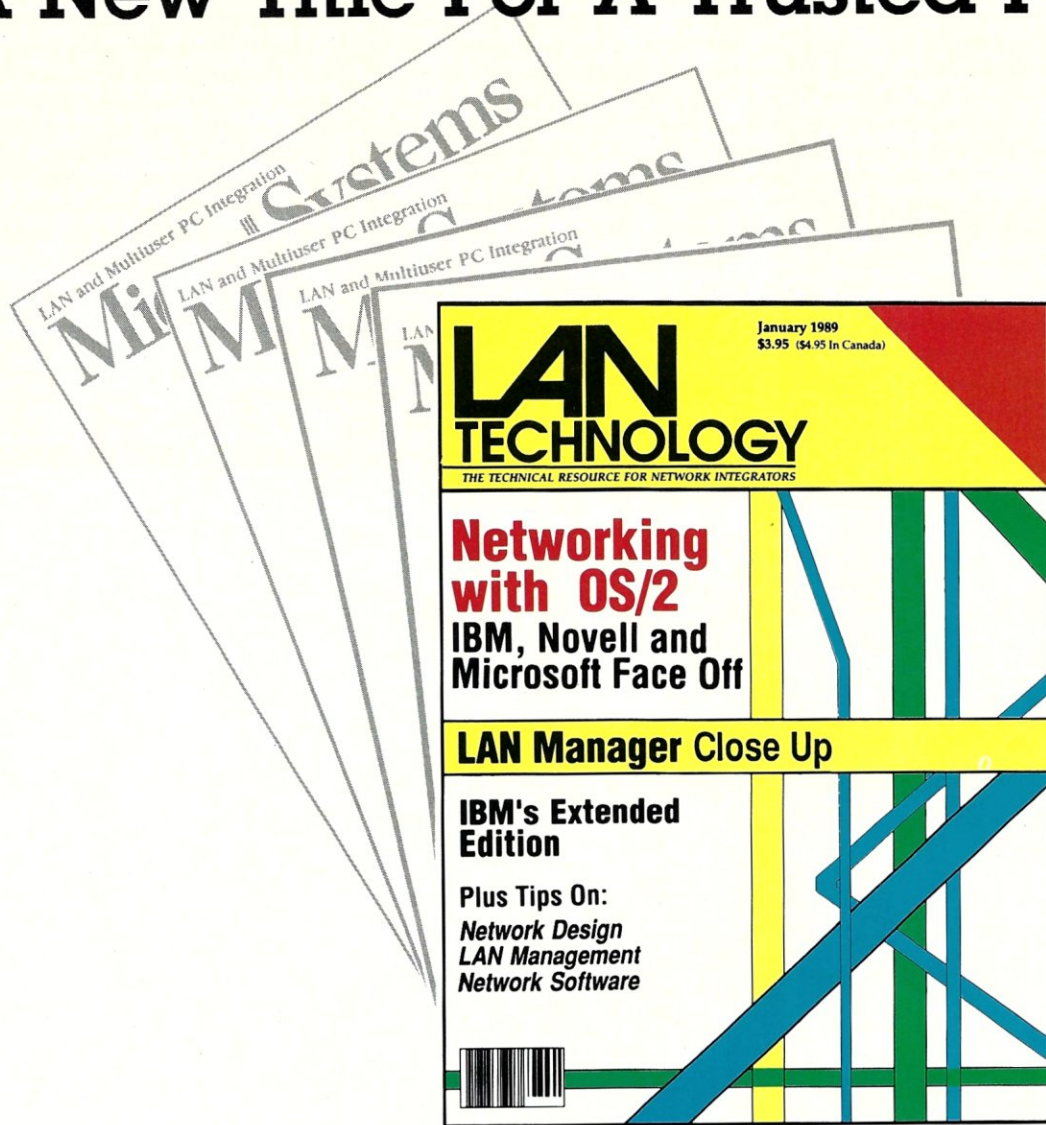
If a station has possession of the token, it can send a packet of information. If it does not have possession of the token, it must wait until the token is passed by the previous station before it can transmit. Basically, token passing systems are "contention-free" systems. Unlike the contention-access scheme of Ethernet and others, each station "waits its turn" until it receives the token. (Ethernet uses a contention-access scheme called CSMA, for Carrier Sense Multiple Access, where any station can transmit if the cable is free. When two stations transmit simultaneously, a "data collision" occurs, and data packets must be retransmitted by both stations.) In token passing systems, network access is guaranteed, while access is random in contention systems. Performance in heavy traffic situations is generally better with token passing systems than with contention systems.

Token passing functions differently in ring systems, such as the IBM Token Ring, than it does in bus systems, such as ARCNET. In a Token-Ring system, the token is passed from one station in the ring to the next station in the ring. It is then regenerated and passed to the following station.

In a token bus system, such as ARCNET, the token acts as permission to transmit. In simplest terms, each ARCNET station has the address of one other station on the network in its Next ID (NID) register. When a station has possession of the token,

Patrick H. Corrigan is a partner in The Corrigan Group — Information Services, an independent consulting firm based in Corte Madera, California, that specializes in local area networks and office automation.

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it can elect to send a data packet to another station. After it sends a packet (and receives acknowledgement) or if it elects not to send a packet, it broadcasts the token across the network to the station whose address is in its NID register. The addressed station acknowledges receipt of the token and begins the process over again.

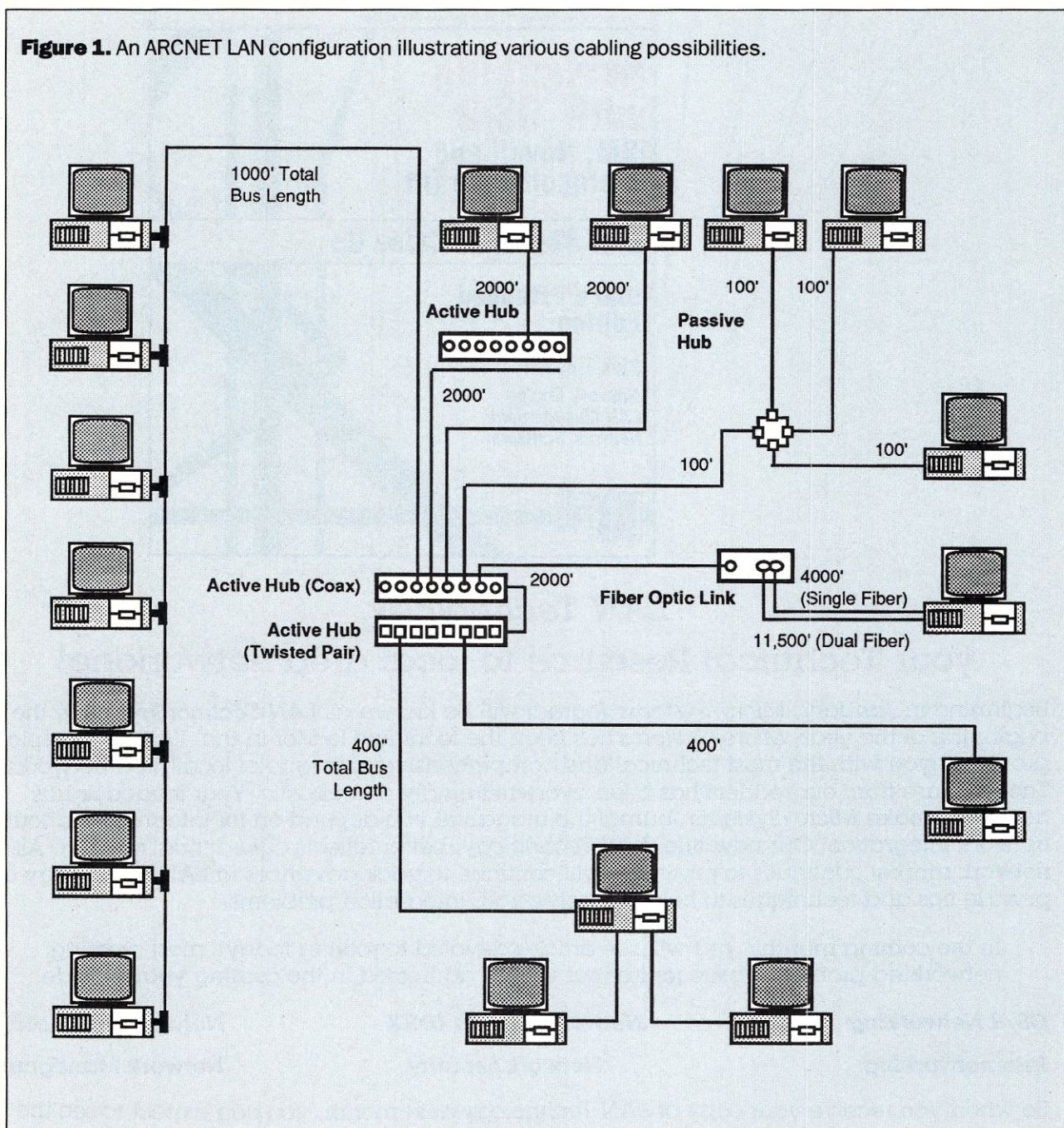
ARCNET dynamically and automatically reconfigures every time a network station is added or removed. When a station is added or "powered on," it transmits a signal that is unambiguously an invalid data pattern and longer than any possible data packet. This "recon burst" interferes with all

communication and prevents any node from receiving the token, thus forcing a reconfiguration. At this point, each station sets its NID register to its own address, then waits up to $146 \times (255 - \text{ID})$ microseconds. Since ARCNET addresses are switch-selectable in a range of 1 to 255, this means that the station with highest address starts the reconfiguration. It sends out a signal, then waits a specified amount of time (usually approximately 75 microseconds) for a response. If it does not receive a response, it increments the address in the NID register (in this case its own address) and starts over. After reaching 255, it increments the address to

0 and continues the process until it finds the lowest addressed station on the network. It then puts that station's address in its address buffer and passes the token. Each node then reconfigures in order. In a worst-case scenario, this process takes a maximum of 61 milliseconds.

When a station is removed from the network the process is much simpler. The station with the address just below the removed station attempts to pass the token and waits for a response. If it does not receive a response, it increments the value in its NID register by one, sends out a signal, and wait for a response. It repeats this procedure until the next

Figure 1. An ARCNET LAN configuration illustrating various cabling possibilities.



station is found, then passes the token to that station.

ARCNET Diagnosis

Fault diagnosis on ARCNET is usually quite simple. Because of the star-cluster topology, it is quite easy to disconnect whole sections of the network to facilitate fault isolation. ARCNET also has a built-in diagnostic tool—the recon burst. In a healthy network, recon bursts should only occur when stations are being added to the LAN (software, such as the Novell NetWare shell, can also force a recon burst). A hardware problem, however, can often cause spurious reconfigurations.

Because of the star-cluster topology, it is quite easy to disconnect whole sections of the network to facilitate fault isolation.

There are several diagnostic software products that, among other things, monitor reconfigurations. These include ARCmonitor from Brightwork Development, Inc. (see the profile of ARCmonitor Plus in *Micro/Systems*, October 1988), ARCDIAG from Microlan Systems, Inc., and ARCView from SMC. By disconnecting sections of the network and monitoring recon bursts, most ARCNET hardware problems can be located.

Extended ARCNET

Many extensions have been added to ARCNET since its original development. Some of these are:

1. **Fiber Optics.** The maximum distance between standard active ARCNET devices (ARCNET controllers and active hubs) is 2000 feet. With fiber optics, that distance can be extended. With single fiber-optic controllers and links, that distance can be extended to 4000 feet, while dual-fiber systems can extend the distance to 11,500 feet.

2. **Linear bus ARCNET.** Another relatively recent development is the linear bus ARCNET card, originally developed by SMC and now produced by many manufacturers. This card uses special circuitry to allow up to eight cards to share the same linear cable. This cable can have a length of up to 1000 feet. Attachment is made using the same type of BNC "T" connector used with thin Ethernet cable. One end of this cable may also be connected to an active hub, thus allowing interconnection with the star-cluster topology, and multiple linear buses may be connected using two-port "active links."
3. **Twisted-pair ARCNET.** ARCNET boards and hubs designed to use unshielded twisted-pair (UTP) telephone wire have been developed by SMC (and, again, are now manufactured by others). These twisted-pair boards may be cabled (up to 400 feet) to special twisted-pair active hubs. Up to 10 boards may be daisy-chained in StarLAN fashion. Unlike other UTP LAN implementations, only a single wire pair is required.
4. **16-bit AT and MicroChannel interfaces.** First released by Thomas Conrad Corporation (16-bit AT) and Pure Data (MicroChannel), similar controllers are provided by other major ARCNET manufacturers. These boards generally provide better performance due to the 16-bit data path and improved packet buffering.
5. **Nodal priority.** SMC now manufactures a 16-bit board designed especially for LAN servers. This board, the PC500FS, can send multiple packets each time it has possession of the token. This means that it can respond to pending requests from multiple workstations on the same round trip of the token.

The future of ARCNET

While many of the enhancements described above contribute to increased performance, ARCNET is still crippled by two factors: its relatively slow (by today's standards) 2.5-megabit transmission speed, and its inefficient 508-byte packet size. Several groups are attempting to correct the situation.

SMC is developing a 5-megabit version of ARCNET that will reportedly have a 2K packet size. Unfortunately, this system will not be compatible with current ARCNET products. Another approach is being taken by the ARCNET Trade Association. They are currently setting the specifications for

an enhanced ARCNET that will initially provide a 20 mbps transfer rate, and a larger packet size, probably 2048 bytes and possibly 4096. The advantage of this specification is that it will be supported on existing coax cabling (and possibly UTP), and it will maintain full downward compatibility with current ARCNET products. The design will allow 20-megabit boards to communicate with 2.5-megabit boards at the slower speed. While the current specification calls for 20 mbps, speeds up to 100 mbps are planned in the future. □

Acknowledgements

Many thanks to Mike Fischer of Datapoint Corp.; John Murphy, formerly of Datapoint, now head of development Performance Technology; Ben Wolfe of the ARCNET Trade Association, and many others for their help with this article.

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by Bob Blacher

Hard-Disk Managers Alternatives

Elsewhere in this issue, Steve Leon reviews commercial products that help you find bad sectors on your hard disk, optimize the disk's interleave, and recover from disasters such as erasing the wrong files or accidentally formatting your hard disk. To paraphrase somewhat from an old TV show, the editors of *Micro/Systems* said to me: "Your mission, should you choose to accept it, is to discuss the free and shareware program alternatives that perform these same tasks." I replied (foolishly): "Sure, be glad to. But, I've never used some of the products Steve reviewed so you'll have to get me copies of those so I can compare them." Fair enough. Copies of SpinRite, Disk Technician, and Mace Utilities were obtained (I already owned Norton's Advanced Utilities Version 4.0), and I set about the task of testing those programs, in addition to those that perform similar tasks on my bulletin board. Several weeks, a half-dozen low-level formats, and countless restores later, here's the report from the hard-disk battlefield.

The Interleave Adjusters

Setting a hard disk's interleave is something you do when you perform a low-level format on a new hard disk. The "accepted wisdom" for standard controllers (MFM encoding) is that XT-class machines should be set for 6:1 interleave, ATs for 3:1, and 386 machines for 2:1. As it turns out, the accepted wisdom is often wrong.

The transfer rate of data from the hard disk can often be improved substantially by changing the interleave

from the above "defaults." One way to do this is to back up all your files, perform a low-level format with a different interleave, test performance with a program that measures transfer rates (like the CORETEST program available on most BBS systems), change the interleave, test again, and so on.

Actually, this process isn't as painful as it sounds. You don't have to low-level format the whole disk to test various interleaves. Instead, choose an interleave, let the low-level program run a couple of minutes, reboot from a floppy, and run CORETEST until you find the best results. Then, let your low-level format complete its run at the interleave you've found to be optimal, FDISK & high-level format the disk (DOS's FORMAT program), and restore your files. All three of my machines had been run through this sequence long ago. It turned out my XT-class machine gave its best performance at 7:1 interleave, my 8-MHz AT at 2:1, and my 20-MHz 386 also at 2:1.

What Steve Gibson's SpinRite promises is the ability to adjust your interleave, and "freshen" your low-level format *without* destroying all your files in the process. In reality, SpinRite will not save any time. The manual process I've described above is probably faster than running SpinRite, especially on a slow, XT-class hard disk. SpinRite can take several hours to do deep testing and interleave adjustment on such a disk. But, Gibson's program is easy-to-use, slick, and friendly, while the alternate approach process I've described may sound a little painful.

How did SpinRite do? I had mixed results with this program. (Version 1.20a was tested). To be fair, let me quote a bit from SpinRite's manual:

A Very Important Warning:
If your hard disk system is in

any way "weird" or if you've experienced problems with other hard disk utilities in the past, we strongly recommend that you back up your hard disk data before performing the low-level reformat for the first time.

That very good advice from the manual is somewhat offset by the proud claim on the cover, in bold print: "Backup and Restore not required!"

I took SpinRite over to a "weird" machine, an XT-class clone with a controller that only knows from 612 cylinder hard disks, but, thanks to Golden Bow's Vfeature partitioning software (with which SpinRite claims compatibility), recognizes all 615 cylinders on a Seagate 225 20-megabyte (MB) hard disk. SpinRite ran and did its diagnostics to see if it could recognize the machine. Yes, it thought all was well. I let SpinRite calculate the optimal interleave and it came up with the same 7:1 that I had chosen long ago. So, without the need to change the interleave, I let SpinRite do the tasks of freshening the low-level format and looking for bad sectors. All went smoothly until SpinRite got itself stuck at a particular spot about half-way through the disk. I waited a long time for SpinRite to get itself unstuck, to no avail. SpinRite's abort command was ignored. So was the old three-finger salute of Ctrl-Alt-Del. There was nothing to do but power down the machine and turn it back on again to see where I stood.

What I had was a disk with one completely unreadable spot right smack in the middle. There was no choice but to reformat the entire drive from scratch, destroying all files with a regular low-level format, FDISK & high-level FORMAT, and then restore all the files.

SpinRite also had trouble with a Vfeature'd drive on another machine, a 40-MB CDC Wren II half-height on a 20-MHz 386. This time, SpinRite refused to run on the D: drive (the second partition) by getting stuck on testing whether a cache was installed (none was). No damage was done during this process.

When that same drive was tested again without Vfeature —this time formatted under DOS 3.3 with normal FDISK partitions —SpinRite ran happily and safely, confirming that my 2:1 interleave was correct and "freshening" the low-level format that I had done about two hours ago (sigh).

My only real criticism of SpinRite is the hyperbole on the cover about not needing to back up before running the program for the first time.

Bob Blacher is a Washington D.C.-based attorney who operates the popular Computer Connections PCBoard bulletin board system. It is quite busy, but those willing to place their modems on redial may call (202) 547-2008.

Compare that to Dave Bushong's Interleave Adjustment Utility (IAU), a shareware program which, each time you load it, forces you to respond that you have read its warnings. The program will make you read the warnings if you answer no.

ILEAVE, as Bushong's program is often called, is more limited than SpinRite in that interleave adjustment is all it claims to do; it does not make any claims about surface defect detection and management. If interleave testing and adjustment is all that matters to you, back up your files first and give ILEAVE a try. The version I tested (1.9a) was smart enough to know it couldn't run on my "weird" XT clone. (When ILEAVE didn't find the hard-disk BIOS where it thought it should be, it aborted. It then gave me the option to run the program anyway with a special command line switch. As I was fully backed up, I did. Not surprisingly, ILEAVE demolished the disk.) ILEAVE ran fine on my 386 when that machine was partitioned with standard DOS 3.3 FDISK. My warnings to back up first apply generally to all products in this class and the fact that I've heard reports from some callers to my BBS that ILEAVE did not run successfully on their machines. But, if you're willing to back up first, ILEAVE is worth a try. The author asks only \$5 - 15 as a shareware contribution, if the program turns out to be useful to you.

Another excellent shareware program is Jim Bracking's HDTEST (Version 1.21 is reviewed here). I'll talk more about this program below in the context of defect management, but it, too, has a reformat-without-losing-data function and interleave adjustment capability.

HDTEST knew it was in trouble on my XT-clone. It told me the diagnostic cylinder looked damaged, a sure sign that it wasn't happy on that machine. Alas, it asked me if I wanted to reformat that cylinder. For purposes of this article, I answered yes, knowing all the while I was in big trouble here. I was—the reformat of the "diagnostic cylinder" went astray and rendered the hard disk unbootable. Time to redo the whole system again (sigh). Bracking's HDTEST ran just dandy on more standard machines, and I've heard few reports of problems with the program.

The Defect Managers

Before talking about Prime Solutions' Disk Technician+, I should admit a rather strong bias: I thoroughly detest copy protection. While the Disk Technician manual has a fairly lengthy explanation of why copy protection

is needed for this product, the fact is the company is now shipping a new program, Disk Technician Advanced, which is not copy protected. (I was promised a copy in time for this review, but it didn't arrive in time.)

Things didn't go well with Disk Technician from the start.

The first diskette sent to me by the company was completely unreadable. Pretty ironic for a company that prides itself on getting rid of "Abort, Retry, Ignore?" messages—that's all I got while attempting to read the diskette on three different machines. The diskette simply wouldn't spin freely inside its jacket, regardless of the normal tricks used to rectify this problem. A second diskette was shipped out by the company.

The package came with a form letter to reviewers which, along with the normal hype found in such letters, said:

Go ahead. Take your worst shot. Try Disk Technician+ on the hard disk system that you have the most problems with—I believe you will soon join me in raving about its amazing results.

I couldn't resist the challenge, could I? So I tried Disk Technician+ on the

weird XT that had defeated all the others. I followed the simple install procedures (including, in this case, loading my hard-disk device driver with which Disk Technician claims compatibility). Disk Technician booted up normally, seemed happy with the machine, and proceeded to run its "monthly" test, which is its deepest level of surface analysis and is required on all new installations. Six hours and 56 minutes later, it put a message on the screen saying that "critical system sectors" had been damaged and that I should restore my files from a backup.

That would have been a little difficult since the hard disk was no longer recognized by DOS as a valid device. A low-level format with another program was required even to get the system to recognize the hard disk again. This, of course, wiped out Disk Technicians' "safety markings" on the hard disk (part of the copy protection scheme) meaning the program would no longer run unless I called Prime Solutions for the code to unlock the program from that machine. I didn't bother since I had no desire to use the program further.

Even forgetting the problems discussed above, I simply can't imagine being disciplined and patient enough

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I certify that the statements made by me above are correct and complete.



Michael Wiener, Associate Publisher

to run the daily, weekly, and monthly tests that Disk Technician+ requires. The program just isn't for me. For a very thorough test of your hard disk for bad sectors (something you shouldn't have to do very often), I recommend checking your local BBS for a copy of P.R. Fletcher's HDTEST program (Version 4.41, not to be confused with Bracking's program of the same name discussed above). Fletcher's program writes a test pattern to every cluster on your disk and then reads it back. It repeats this test 20 times for each cluster, without destroying any data—if all goes well (again, backing up before you use this program the first time is a good idea). Needless to say, that testing process is going to take a long time,

*I simply can't
imagine being
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and monthly
tests.*

but if no new bad clusters are found, you can be pretty sure your hard disk is in very good shape after being put through this torture and you shouldn't have to run the full test often.

Bracking's HDTEST 1.21 also has both non-destructive and destructive defect testing capabilities. In fact, it finally found a marginal cluster on an 80-MB Seagate in my AT that had been giving occasional read errors for a long time, yet this defect had eluded previous efforts at detection. Indeed, I can recommend this package wholeheartedly. It's one of the most versatile in the group. While its non-destructive defect testing is not as extensive as Fletcher's, it also has interleaved adjustment, low-level formatting, controller diagnostics, and other useful capabilities.

Using any of these programs on a day-to-day basis would be overkill. A quick run of Norton's DiskTest or Mace's REMEDY will read all clusters on your hard disk and catch the obvious errors. A little program by Samuel Smith called DTEST (v1.4) performs much the same task but also identifies "slow" sectors—those that DOS must read more than once. DTEST is

available from BBS systems and even includes its Turbo C source.

The General Purpose Packages

No discussion of hard-disk problems would be complete without some mention of accidentally formatting your hard disk or erasing files. Fortunately, DOS is making it a little harder to format your hard disk by accident. In addition to warnings, DOS 3.3 and later will require you to enter the hard drive's label before allowing the format to continue. But, if you manage to format a hard disk anyway when you didn't intend to, both Norton's Format Recover and Mace's Unformat may save your day if you've kept their File Allocation Table (FAT) information current by running the required programs frequently.

Similarly, both Norton and Mace have excellent programs for unerasing files that you deleted by accident. I find Norton's Quick Unerase (QU) particularly easy to use when I realize immediately that I've erased something by accident. But, I've also seen it fail to reconstruct a file properly in that same situation. For valuable data, bringing up the full NU program in Norton Utilities and following its prompts carefully or using Mace's UNDELETE is a good idea.

There is an excellent shareware package to look for if you don't already own Norton, Mace, or the like. Professional Master Key v2.1a (PMK21A.ARC on most BBS systems) has a truly polished user interface that combines the best of the commercial programs. PMK has the unformat command that was pioneered by Mace, and it can unerase files as well. It also has the disk sector editing that's the true strength of Norton's main NU program, all tied together by a menu shell similar to Norton's NI (Norton's Integrator). It lacks the disk testing, file defragmentation, and other capabilities of Norton Advanced and Mace, but if those aren't what you need, Professional Master Key may fit the bill (and, a small bill at that—only a \$25 shareware contribution is requested). And, if all you want is to be able to unerase files on a standard hard disk, Eric Gans' UNERASE program (UNERA12.ARC) is quick and easy to use and will do the job for you. It's also free!

Note: Some of the programs discussed above will not function with DOS 4.0 due to changes made in the FAT to allow portions larger than 32MB. By the time this article appears, revised versions of all the programs mentioned should be available. □

Did you find this article particularly useful? Circle number 12 on the reader service card.

(continued from page 8)

that hardware is expected to be less reliable than software. It seems wholly inconsistent, then, to use any technique that increases the probability of data loss through hardware failure.

From a programmer's point of view, disk caching may be acceptable because it shifts blame for the data loss from the software to the integrity of his customer's hardware over which the programmer may claim he has no control. A user, too, may agree that trading data integrity for improved performance due to disk caching is worthwhile, but then again, he may not. An informed user may conclude that disk caching is too risky. However, not all users are informed, and the decision to cache or not to cache is all too often taken out of his hands.

At SemiDisk Systems, we have long advocated disk emulation over disk caching. (As a manufacturer of dedicated disk emulators, our bias is obvious.) A disk emulator can provide the performance boost that a LAN server needs, but disk emulation techniques that partition memory, like VDISK, aren't the solution either. Such implementations are subject to the same corrupting influences as a disk cache. For example, any data stored on a VDISK or in a disk cache gets trashed during a reboot by the memory test.

Novell's own BATRAM, from Santa Clara Systems and our SemiDisk are examples of disk emulators that do not trash data when the host computer gets into trouble. We routinely supply dedicated disk emulators that run under DOS 2.x and 3.x in sizes up to 32 MB per logical drive. When our disk emulators are equipped with our Battery Backup Unit (BBU), data integrity is no longer dependent on the fortunes of the host or its power supply. The desire for performance and data integrity does not have to pose a dilemma.

Ray Pearl
SemiDisk Systems, Inc.
Beaverton, Ore.

From the Author: Mr. Pearl's points are well-founded. Software and hardware must work in harmony, but they are different species and suffer from different diseases. If properly designed and implemented, software should NEVER fail within its specifications. Being an intellectual machine rather than a physical one, software does not succumb to power surges or drops, physical or chemical abuse, worn parts, heat, or any other real-world aggravations that may cause a physical machine to fatigue or utterly fail. Should the hardware fail in a manner peculiar enough to mutate the software into something

that does not function properly, it is merely the binary copy of the software that is corrupted and not the software itself. As software developers, it is our first duty to make sure that the software itself is faultless within its design requirements. It is then care and pride that drives us to add muscle to the software to compensate for the hardware's shortcomings.

This leaves the developer between a rock and a hard place when it comes to choosing corners in the trade-off triangle. How do you balance Cost, Integrity, and Performance. Obviously, the higher the integrity of the hardware, the higher the cost. If additional facilities must be added to the software to compensate for the hardware's integrity deficiencies, the cost is further increased.

At present, many users who rely on computers have become aware of hardware frailties (through experience or horror stories) and simply will not accept a system that doesn't offer a cost-effective and timely method to recover from catastrophes and glitches. Additional hardware solutions, such as uninterruptible power supplies (UPSs) or streaming tapes, may be added to help prevent or recover from such situations. In discussions with many clients, a network was the only cost-effective solution to their problem. Making them aware of the frailties of networks and suggesting the addition of hardware to cope with these problems was also acceptable to the clients.

For most applications, a Novell file server should have some sort of data backup (i.e., streaming tape) and a UPS with line conditioning and a minimum of 10 minutes of surplus power over the normal system shut down time. With these two additions, the compromises of integrity, performance, and cost become viable.

Mr. Pearl does offer some worthy alternatives, but he seems to overlook the customers' concern for cost as well as capacity. Based on the information in his letter, the alternative he suggests may work for others, but it would not work for us simply because we have developed systems for our clients in which a single file consumes more than 32 MB. Under current market conditions, we think that disk emulators also could be suffering from the overinflated prices of RAM. Consider that a Novell BATRAM costs about \$7,200 as opposed to \$300 to \$400 for an Seagate ST-255 hard disk. All in all, no one we've ever known has been able to connect all the corners of the trade-off triangle mentioned above. We are certainly open to other suggestions and eager to evaluate them.

Ed Rought and Tom Hoops

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New Products

New Software Products

Abraxas Ships Toolkit for SQL and dBASE III Plus

Abraxas Software Inc. has begun shipping its toolkit for SQL and dBASE III/Plus. The toolkit is designed to be used with Abraxas' PCYACC and MACYACC products. PCYACC generates ANSI C source code optimized for Microsoft, Borland, and Lattice compilers; MACYACC generates ANSI C source code for MPW, Lightspeed, and Aztec C compilers. The toolkit supplies example programs and provides a means to easily support existing database software applications.

PCYACC and MACYACC retail for \$395. For more information, contact **Abraxas Software Inc.**, 7033 S.W. Macadam Avenue, Portland, OR 97219; (503) 244-5253.

Circle reader service #265

Priam Releases Novell DCB Drivers

Priam Corporation, the Winchester disk drive manufacturer, now has software drivers for Novell's Disk Coprocessor Board (DCB). A DCB in a Novell file server can support up to four disk drives, and the Priam software driver allows network administrators to take advantage of SCSI-based Winchester disk drives to expand storage capacity. Priam's SCSI-based drives are available in three capacities: 178.6, 280.7, and 382.78 megabytes.

The Priam DCB software drivers are being added to Priam's Novell driver kit, which sells for \$295. The kit is available for both PS/2 and AT host machines. For more information, contact **Priam Corporation**, 20 West Montague Expressway, San Jose, CA 95134; (408) 434-9300.

Circle reader service #266

Network Traffic Cop For Licensed Applications

Network Licensing Manager is a new product from Highland Digital that allows networked UNIX workstations to share proprietary licensed applications software over Ethernet. The Network Licensing Manager acts as a software librarian to allow users to "check out" licensed applications over the network. The UNIX utility is designed to be built into an applications developer's products. For example, the Network License Manager will allow an end user who has purchased five product licenses to make those licenses available to network workstations. When that application is accessed by network users, the Network License Manager can identify users, the time they checked out the application, and deny access to more than the licensed number of users. Access priority also can be established. A single Network License Manager can act as a network server controlling a variety of packages from different vendors. It also allows heterogeneous computers systems to participate in using

local applications, and it provides layered software support. The overhead it imposes is minimal, requiring only one server process per "server node."

Network License Manager has a list price of \$10,000 for binaries. Source code is available. For more information, contact **Highland Digital**, 940 East Meadow Drive, Palo Alto, CA 94303; (415) 493-8550.

Circle reader service #267

Apex C Library Facilitates dBASE Development

The Apex Database Library (ADL) from Apex Software is a new library of functions to aid C programmers in creating, accessing, and updating dBASE files. ADL makes it possible to retrieve one field from the database, or to access the entire record reformatted into a standard C structure. It also automatically accesses and updates index files and includes a dBASE expression parser for index file support. A tunable caching algorithm also offers the programmer complete control over speed and space, and makes caching available on a per-database or per-index level. Support is provided for Microsoft C Version 4.0 compilers. The minimum hardware requirement is an IBM PC or compatible with 128 kilobytes of RAM and it needs DOS Version 2.0 or later.

The ADL is priced at \$395 without source code, or \$795 with source code. For more information, contact **Apex Software Corporation**, 4516 Henry Street, Suite 308, Pittsburgh, PA 15213; (412) 681-4343.

Circle reader service #268

New Hardware Products

Quadram Unveils New Mainframe Link

MainLink II, a 3270 micro-to-mainframe emulation board, has been introduced by Quadram. MainLink II is IBM and IRMA hardware compatible, and works with

the IBM PC, XT, AT, and the PS/2 Model 30 and compatibles. A MicroChannel version, the MainLink IIm, is also available. To accompany the emulation board, MainLink II/MLe software handles emulation and file transfer. It also has special features for PC users unfamiliar with mainframe communications, such as a smart menu and On-Line Help.

The MainLink II emulation board costs \$395 (\$495 for the MicroChannel version). The MLe software package is available for \$150 when purchased with the hardware. For more information, contact **Quadram**, 4355 International Blvd., Norcross, GA 30093; (404) 564-5566.

Circle reader service #269

Astrocom Multiplexers Conform to AT&T SDM

Astrocom has added two single-ended multiplexers to its product line. The 8100 and 8200 Subrate Digital Multiplexers link one site to as many as 20 separate remote locations using AT&T's Subrate Data Multiplexing (SDM) option. With this new system, a single Digital Service Unit/Channel Service Unit (DSU/CSU) is needed at the host and a DSU/CSU is used for each remote location. The 8100 interfaces to the network through any DS0B data port. The 8200 transmits data directly into the DDS through an integrated DSU/CSU and can be used for point-to-point multiplexing. Both units have a 20-port capacity with modular upgrades available in 5-port increments. Both feature asynchronous secondary channels for network management and diagnostics, a software-selectable configuration, and channel data rates from 2400 to 19,200 bps.

Prices for the two multiplexers begin at \$3,350. For more information, contact **Astrocom Corporation**, 120 West Plato Blvd., St. Paul, MN 55107-2092; (612) 227-8651.

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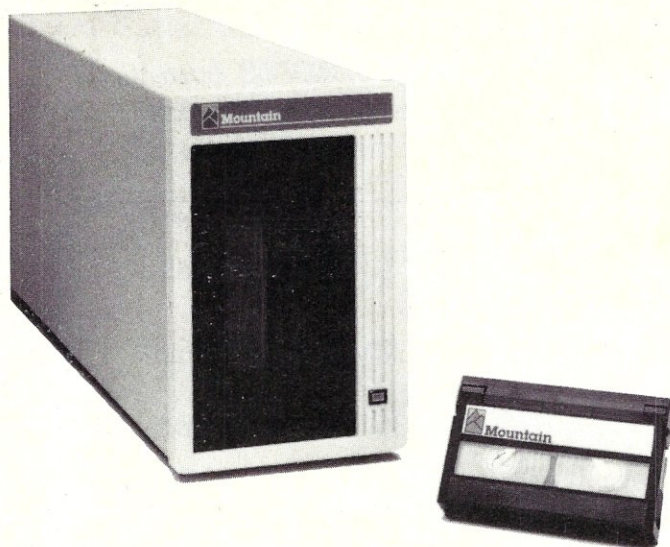
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Series 2100 Tape Backup System



PS/2-Compatible Ethernet Offered by Simple-NET

Simple-NET's EtherLAN Plus/MCA is a turnkey, 10-million-bits-per-second networking system that comes as a full-sized add-in card, 25 feet of "thinwire" cabling, SimpleNET's NetBIOS interface, the SimpleWARE network operating system, and installation and user guides. On-board memory buffering eliminates the need for direct memory access channels. SimpleWARE also includes a complete electronic mail package. As with Simple-NET's EtherLAN Plus, EtherLAN Plus/MCA meets all IEEE 802.3 standards and is compatible with 16-MHz and above 386 machines. Company sources indicate that this network solution also takes full advantage of the MicroChannel architecture of IBM's PS/2.

The single-unit price for this turnkey network is \$899.95. For more information, contact **Simple-NET Systems**, 545 West Lambert Road, Suite A, Brea, CA 92621; (714) 526-5151.

Circle reader service #271

Store 2.2 Gigabytes on One 8mm Tape

The series 2100 high-capacity, high-performance, external tape backup sys-

tem was unveiled recently by Mountain Computer, Inc. This tape drive can store more than 2.2 gigabytes of data on a single, 8-millimeter tape cartridge. The unit is compatible with AT-bus computers and can store data at an average of 13 megabytes per minute using a SCSI interface, with data bursts at a transfer rate as fast as 1.5 megabytes per second and a sustained rate of 246 kilobytes per second. The storage subsystem includes FailSafe software, a SCSI host adapter and interconnect cable, and the drive that fits in a 5 2/3-inch footprint cabinet footprint, including power supply. The tape drive uses helical-scan technology (similar to videotape) that supports higher track and bit density on the tape. The Series 2100 also has Reed-Solomon error-correction

code that provides fewer than one unrecoverable error in 200 cartridges.

The series 2100 tape backup system retails for \$6,495. For more information, contact **Mountain Computer, Inc.**, 240 Hacienda Avenue, Campbell, CA 95008; (408) 379-4300.

Circle reader service #272

ALANtec Extends Span of Ethernet Bridge

ALANtec has introduced the SMARTbridge 2000, an improved version of its MAC Layer bridge to allow extended transmission of Ethernet LAN protocols beyond 2.5 kilometers. This increases the distance between bridges transmitting at 10 megabytes to 10 kilometers. The SMARTbridge 2000 also features a router pass-through capability; rather than locating the router between the network management workstation and the bridge to block software control access to the bridge, the router connections become transparent to bridge control commands. These means ALANtec bridges can be managed remotely through IP routers anywhere on a TCP/IP network. The SMARTbridge 2000 also offers enhanced graphic display output of network statistics. In addition, it features selective filtering to manage data by packet type, source address, destination address, packet length, and broadcast packets. The SMARTbridge 2000 includes self diagnostics, self-learning routing, filtering and forwarding, redundancy, remote monitoring, multiple network statistics and analysis, and remote configuration. The bridge uses an Intel 80286 processor running at 20 MHz and can process 13,000 packets

per second.

The SMARTbridge 2000 is available for \$6,280, including network management protocols, local control software, and optional display monitor and keyboard. It is also available as an add-in PC card with bridging software for \$3,280. For more information, contact **ALANtec**, 101 Hammond Avenue, Fremont, CA 94539; (415) 770-1050.

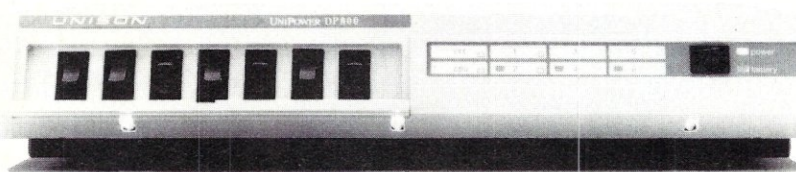
Circle reader service #273

Unison Targets PC LAN Market for UPS Line

Unison Technologies Inc. has introduced the UniPower DP series of three uninterruptible power supply (UPS) models for personal computers. The DP 600 provides protection for single PC workstations. The DP 800 includes a LAN interface cable and is designed to protect file servers. At the high end, the DP 1000 is designed to protect multi-peripheral applications, such as LANs with printers, plotters, and auxiliary storage devices sharing the same power line. All models in the line are compact, measuring 18 inches by 2.9 inches by 16.5 inches, and weigh 32 - 42 pounds. Each unit comes with eight peripheral power outlets and a sealed lead-acid battery. Visual and audio alarms provide an alert to power fluctuations. There is also a remote power on/off feature with modem spike and surge protection, control via a modem.

The UniPower DP 600 sells for \$695; the DP 800 for \$895; and the DP 1000 for \$1,095. For more information, contact **Unison Technologies, Inc.**, 23456 Madero, Mission Viejo, CA 92691; (714) 855-8700.

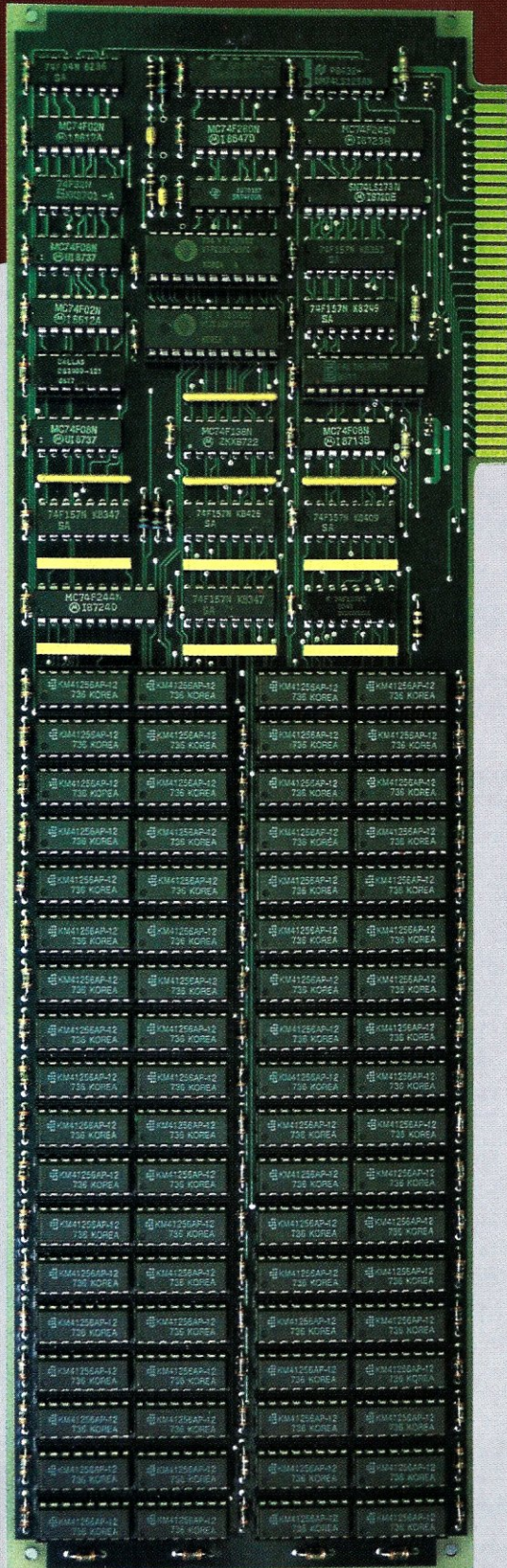
Circle reader service #274



UniPower DP800

X-BANDIT

Designed for the EMS 4.0 Standard



DESIGN PHILOSOPHY

• The Teletek X-Bandit was specifically designed to utilize the advanced features of the Lotus/Intel/Microsoft EMS 4.0 Specification. It is available in both 8 and 16 bit versions for use in the IBM XT, AT, and compatibles.

MEMORY

- Segmented Memory Mapping allows the user to fill out unused memory segments between 640K and 1 Megabyte.
- Split Memory Addressing allows the user to fill out conventional memory to 640K.
- Extended Memory Addressing is available for the PC/AT version.
- 2 MB capacity in a single slot. Up to 8 MB per system.
- Parity checking.

SOFTWARE

- Easy menu-driven auto configuration software.
- Device driver includes print spooler and RAM drive.
- Supports multitasking with the appropriate shell-resident software package.

SPEED

- 6/8/10/12 MHz speed with 0 wait states. 16 MHz speed with 1 wait state.

WARRANTY

- One year parts and labor.

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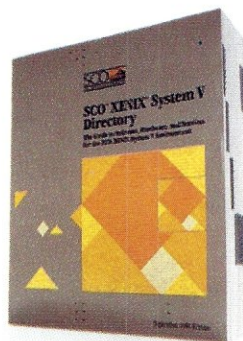
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